AMERICAN SAMOA WATERSHED PROTECTION PLAN

Volume 4: Stormwater Management Evaluations

Nuuuli Watershed
Daniel Inouye Industrial Park
Pago Pago Watershed
Vatia Watershed
Tula Watershed
Leone Watershed

Volume 1: Watersheds 1-23

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Volume 3: Watersheds 36-41

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CHAPTER ONE
INTRODUCTION

PURPOSE

The American Samoa Government continues to strive for a reduction in the amount of sediments, nutrients, bacteria, and other pollutants that are discharged into the nearshore waters of all islands in the Territory of American Samoa. Bacteria pose a potential threat to public health in some nearshore areas where public fishing and water recreation takes place. The discharge of sediments and nutrients into the nearshore waters of American Samoa also impacts the health of coral communities and other marine organisms. These discharges are most prevalent during and following heavier rainfall periods.

The recent Watershed Protection Plan for American Samoa pointed out that the future use of detention of stormwater flows is an important resource management opportunity. Where feasible, increased stormwater detention affords the opportunity to settle out of some sediments and nutrients prior to the discharge of stormwater flows into the nearshore waters. The preparation of conceptual plans for detention ponds in several watersheds in the Territory were recommended to determine:

- stormwater flows within selected watersheds;
- the type and location of proposed detention ponds;
- required improvements to related stormwater management facilities;
- quantify potential project benefits; and,
- order-of-magnitude costs for the construction of proposed improvements.

This stormwater management plan represents an effort of the American Samoa Government to evaluate the feasibility of proposed stormwater detention opportunities and improved stormwater management in several drainages on the Island of Tutuila. The selected watersheds do not include all areas in the Territory where the detention of future stormwater flows may be feasible. The American Samoa Environmental Protection Agency intends to seek funding for:

- future evaluations of other drainages and wetlands; and,
- the future design and construction of stormwater management improvements in selected drainages that are determined to be feasible and cost effective.

A second intent of this plan is to provide specific guidance to traditional leaders, e.g., family sao and village council, and various ASG agencies that make important decisions concerning future land uses in inhabited villages and undeveloped watershed areas. For example, some lands in all watersheds of the Territory are unsuitable for land use because of steeper topography, soils susceptible to greater erosion, and the proximity of local streams that discharge turbid runoff and sediments to the nearshore waters. Land use recommendations are presented in this report to help facilitate and promote the conservation of natural resources in the selected watersheds, as well as address anticipated demands for residential, agricultural, recreational, commercial, industrial land uses.

PROJECT SCOPE AND REPORT ORGANIZATION

The Stormwater Management Plan examines several potential opportunities for stormwater detention and/or improved stormwater management in selected drainage areas. These include:

- the east side of Nuuuli watershed between Vaitele Stream and Amaile Stream;
- Tafuna Industrial Park;

- Vaipito Stream in the Pago Pago watershed;
- two wetlands in the Vatia watershed;
- one wetland in the Tula watershed; and
- Leafu Stream and Pala Lagoon in the Leone watershed.

This stormwater evaluation report presents relevant information, conclusions and recommendations for each of the six drainage areas where potential stormwater management improvements were evaluated.

Section One provides an overview of the purpose, scope and methodology used to make the stormwater management evaluation.

Sections 2 through 7 provide separate analyses for each of the six drainages and wetland areas that were evaluated for potential stormwater detention opportunities and related improvements to stormwater management facilities. Each stormwater analyses includes:

- selected hydrologic and drainage characteristics;
- an overview of relevant watershed issues;
- estimated rates of stormwater runoff and sedimentation for variable storm events;
- the type, size and condition of existing stormwater facilities;
- the type and location of recommended detention opportunities and/or stormwater facility improvements;
- estimated order-of-magnitude costs for facility improvements, new construction and long-term operation and maintenance; and,
- recommended land uses.

METHODOLOGY

General

The information presented in this report brings together selected information relevant to stormwater and land use management for several drainages and watersheds on the Island of Tutuila. Pedersen Planning Consultants initially reviewed available information from the Watershed Protection Plan for American Samoa, stream flow data, stormwater and flood studies, as well as other relevant land use and infrastructure plans. Various types of information were also correlated through the use of the American Samoa Geographical Information System (GIS) which was developed by Pedersen Planning Consultants (PPC) in conjunction with its preparation of the Watershed Protection Plan for American Samoa.
Subsequently, PPC surveyed each of the selected drainages and potential detention areas in May, 1998. During these surveys, selected drainage characteristics, drainage structures, and wetlands were documented and photographed for future reference.

Land uses and other significant conditions were documented in the watersheds that contained the selected drainages and potential detention areas. Land use data gained from island-wide land use surveys by Pedersen Planning Consultants in 1995 and 1996 was correlated with more recent changes in land use during the 1996-1998 period.

Informal discussions with traditional village leaders and/or residents in Vatia, Tula, and Pago Pago were made to describe the purpose of stormwater evaluations, as well as gain greater insights of local stormwater characteristics, land uses, and related watershed management issues.

Stormwater Modeling

Potential surface runoff and sedimentation from 2,10, 50 and 100-year storm events was determined through the computer modeling of the seven drainage areas that were selected and evaluated for potential stormwater detention opportunities. This analytical process involved the use of available information from the U.S. Geological Survey, as well as software programs developed by Haestad Methods, Inc. and Civil Software Design.

In 1996, runoff criteria and equations were published by the U.S. Geological Survey Water for various streams in American Samoa (Wong, 1996). The USGS report by Wong was intended to provide *"....updated streamflow at gaged and low-flow partial-record sites and to describe methods that can be used to estimate streamflow characteristics at miscellaneous and ungaged sites"* (Wong, 1996).

The stormwater modeling process used by PPC represents the ordinary least-squares regression procedures outlined by Wong. This methodology allowed the development of the final regression equations for estimating peak flows for 2, 10, 50, and 100-year storm events.

Pedersen Planning Consultants (PPC) used USGS regression equations, developed by Wong, in combination with TR-55 and SEDCAD4 software programs. The stormwater flows were initially estimated using the regression curves. Hydrographs were subsequently developed and routed through the watershed basins, streams and detention ponds. During this process, sediment loadings were estimated and applied to the modeling. The sediment loadings are a function of runoff, slope, soils, duration of events, cover, agricultural practices, and other related variables.

The Sedcad4 software program, developed by Civil Software Design, was the primary computer modeling tool used in this stormwater evaluation. This program was primarily used to develop hydrographs and determine anticipated sediment loadings for 2, 10, 50, and 100-year storm events. Using estimated stream flows from Wong, the runoff was routed through reaches and detention ponds to model potential local and adjacent effects during the storm events.

The runoff modeled by Sedcad4 was accounted for at each junction and was added to or subtracted from upstream flows. The flows were routed through detention ponds and outlet through metering devices. These metering devices allowed the water to be controlled and settle out larger sediment particles. This approach reduced the estimated amount of material introduced in the nearshore waters adjacent to local stream mouths or the outlets associated with wetlands.

The Haestad programs included Flow Master and Culvert Master. These programs were primarily used to estimate the severity of conditions at various structures under potential runoff scenarios.

Study Limitations and Differences With Other Available Data

Higher standards of error are associated with estimating runoff in American Samoa because of the lack of stream flow data. There is a need for additional and continued gaging of streams on the Island of Tutuila to improve the reliability of future hydrologic modeling. With additional data, programs such as TR-55 can be modified to better estimate and predict storm events. Results from future hydrologic models can facilitate better local decisions concerning stormwater management and the development of future stormwater detention opportunities.

Predicted estimates of stormwater runoff by Pedersen Planning Consultants differ from estimates developed earlier by the U.S. Army Corps of Engineers, Honolulu District. These differences primarily result from the use of different modeling techniques and assumptions.

Cost Estimates

Order-of-magnitude cost estimates were developed for proposed stormwater facility improvements. These estimates were based upon the conceptual designs developed by PPC for each selected drainage area, as well as discussions with representatives from two general building contractors on the Island of Tutuila.

Order-of-magnitude development costs are expressed in 1998 US Dollars and are expected to deviate between 15 and 25 percent from actual construction costs.

CHAPTER TWO
NUUULI WATERSHED

STUDY AREA LOCATION

The Nuuuli watershed planning area, which is defined by natural resource managers in American Samoa and the American Samoa Watershed Protection Plan, includes approximately 6.7 square miles of land area (Figure 2-1). It contains approximately 13 streams and related drainage areas.

STUDY OBJECTIVE

This stormwater evaluation focused upon the stormwater runoff and sedimentation that discharges into Pala Lagoon. The feasibility and value of potential stormwater detention opportunities were examined to determine viable stormwater management improvements that will:

- reduce the discharge of sediments into Pala Lagoon;
- reduce flooding along the primary shoreline roadway on the east side of the Nuuuli watershed planning area.

HYDROLOGY

General Drainage Characteristics

The thirteen streams in the Nuuuli Pala watershed drain moderate and steeper slopes of the watershed that generally lie upslope of the primary shoreline roadway. Vaitele Stream, as well as five streams on the east side of the watershed planning area, discharges into Pala Lagoon.

Vaitele Stream Drainage

Vaitele Stream is the primary drainage in the Nuuuli watershed planning area. This drainage encompasses approximately 1,644 acres of land area. The main branch of this stream extends up to approximately 1,400 feet above mean sea level from its stream mouth which is immediately adjacent to ASG's Tafuna Correctional Facility and Lion's Park.

Surface flows from Taumata Stream and its upper stream branches also discharge into Vaitele Stream along the south side of the primary shoreline roadway. Taumata Stream flows through Malaeimi Valley before it empties into the main stem of Vaitele Stream.

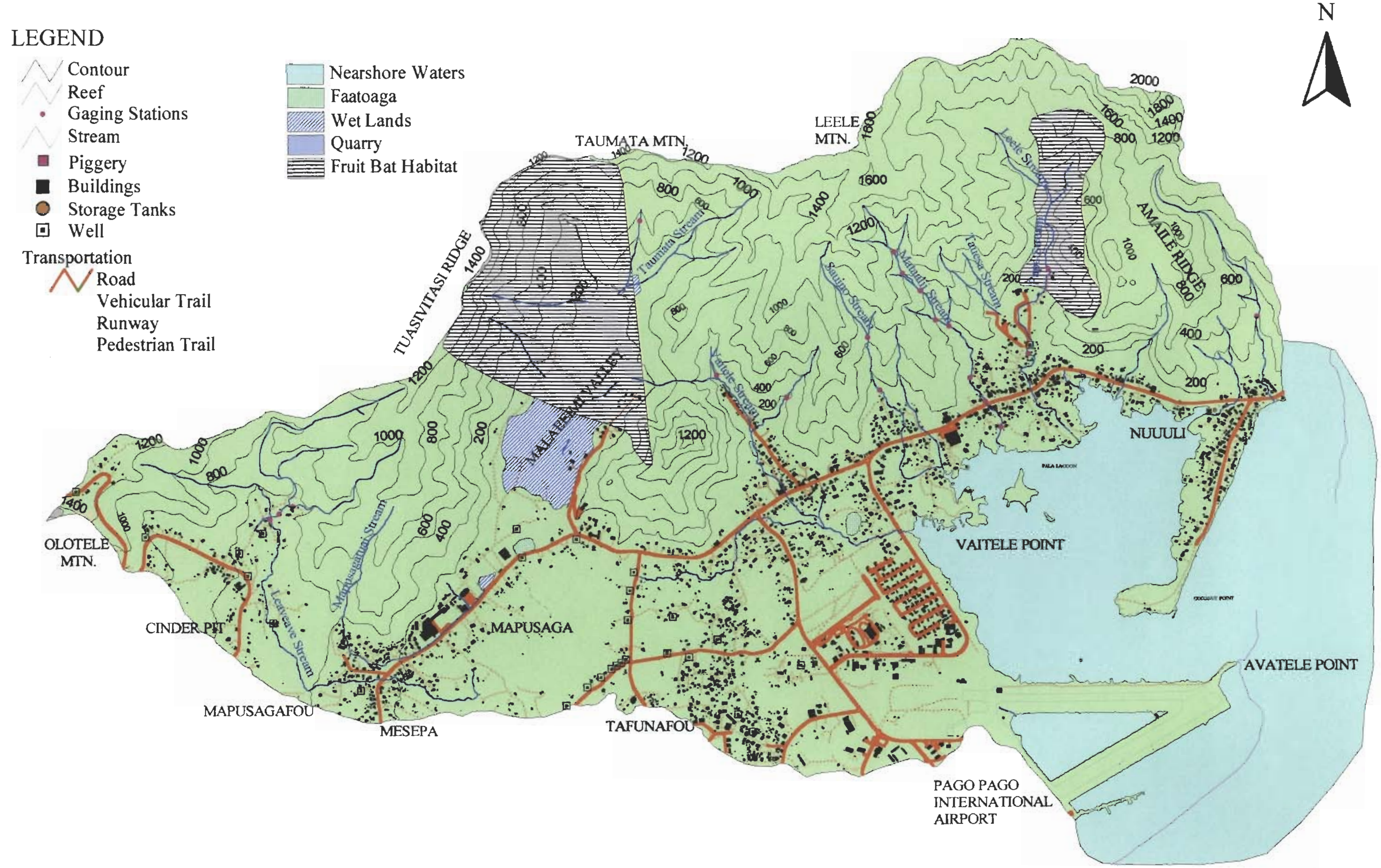
Mapusagatuai Stream, which drains a portion of the southeast slopes of Tuasivitasi Ridge, is also considered a part of the Vaitele Stream drainage. Surface flows drain along the south and east side of the American Samoa Community College complex where flows discharge, pond, and percolate into the substratum of a lowland area on the north side of the primary shoreline roadway. It is believed that groundwater and some surface flows in the Mapusagatuai drainage ultimately are transported into the lower Taumata Stream drainage.

Drainage Area East of Vaitele Stream

Several streams east of Vaitele Stream include Sauino Stream, Mataalii Stream, Tauese Stream, Leele Stream, Papa Stream, Sagamea Stream, one unnamed stream (Stream 27A), and Amaile Stream. These streams and their respective drainage areas represent a 1,211-acre drainage area. Five of these streams (Sauino, Mataali, Papa, Sagamea, and stream 27A), discharge directly into Pala Lagoon (Figure 2-1).

Stream Flows

In 1996, the U.S. Geological Survey estimated the median stream flow for nine streams in the Nuuuli watershed planning area (Table 2-1). These estimates were based upon historical, intermittent stream flow measurements made by the U.S. Geological Survey.



American Samoa Geographical Information System

Miles
Scale: 1:32,000

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Nuuuli Pala Watershed 27

Existing Conditions

Figure 2-1

TABLE 2-1
MEDIAN STREAM FLOW ESTIMATES
STREAMS IN THE NUUULI WATERSHED

Stream	USGS Gage Station	Gage Location	Stream Flow Measurements (number)	Estimated Median Flow (cfs)
Amaile Stream	16945000	0.3 mile upstream from stream mouth	14	0.45
Papa Stream	16944200	500 feet downstream of Papa/Tauese Stream confluence	N/A	1.30
Tauese Stream	16944000	0.3 mile upstream of Tauese/Papa Stream confluence	30	1.48
Mataali Stream	16943000	0.6 mile upstream from stream mouth	17	0.60
Sauino Stream	16942000	0.6 mile upstream from Pala Lagoon	17	0.25
Vaitele Stream	16937000	1.1 mile upstream from stream mouth	19	0.67
Vaitele Stream	16938000	0.2 mile upstream of a confluence with a left-bank tributary	17	0.26
Taumata Stream	16939000	2.2 miles upstream of Vaitele/ Taumata Stream confluence	14	0.12
Taumata Stream	16940000	0.5 mile upstream of a left-bank tributary confluence with Taumata Stream	13	0.22
Mapusagatuai Stream	16941000	1.2 mile upstream of Mapusagatuai Stream/Taumata Stream confluence	16	0.23
Leaveave Stream	16936000	0.1 mile upstream from Leaveave Stream/Puna Stream confluence	15	0.33

Source: Wong, 1996

The preceding estimates of median stream flow rates suggest higher stream flow discharges occur along Papa Stream. However, during and following heavier rainfall events, stream flow discharges in the Nuuuli watershed are significantly greater along the Vaitele Stream drainage.

Stormwater Runoff

Stormwater runoff that discharges into Pala Lagoon is generated from heavier rainfall events that occur within the drainage area associated with Vaitele Stream and the five streams east of Vaitele Stream. The total drainage area encompasses approximately 2,855 acres of land.

Computer modeling of the Vaitele Stream drainage by Pedersen Planning Consultants suggests potential stormwater flows that range between 1,581 cubic feet per second (cfs) for a 2-year storm event and 4,332 cfs for a 100-year storm. The drainage area east of Vaitele Stream contributes a stormwater flow of 1,868 cfs during a 2-year storm and 5,207 cfs for a 100-year storm (Table 2-2).

TABLE 2-2
STORMWATER RUNOFF DISCHARGES INTO PALA LAGOON
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Vaitele stream mouth	1,581	2,437	3,902	4,332
5 streams east of Vaitele:				
Sauino	278	427	693	777
Mataalii	351	536	868	973
Papa	739	1134	1847	2072
Sagamea	279	426	689	772
Stream 27A	221	338	548	613

Source: Pedersen Planning Consultants, 2000

Correlation With Other Stormwater Runoff Estimates

A flood insurance study was published by the Federal Emergency Management Agency (FEMA) in May, 1991. This study included flood risk data for selected areas on the Island of Tutuila that were intended to:

- facilitate the establishment of actuarial flood insurance rates; as well as,
- provide information that could be used for local floodplain management efforts in American Samoa.

The U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses in 1987 that supported the FEMA study. The 100-year peak discharges calculated for the streams that drain into Pala Lagoon were somewhat higher than those determined by Pedersen Planning Consultants in 1998 (Table 2-3). The U.S. Army Corps of Engineer estimates were about 16 percent higher than the 100-year flows calculated by PPC for the Vaitele Stream mouth and approximately 28 percent higher for the cumulative discharge from the five streams east of Vaitele Stream.

TABLE 2-3
U.S. ARMY CORPS OF ENGINEER ESTIMATES
100-YEAR STORMWATER FLOW

Flooding Source and Location	Drainage Area (Square Miles)	100-Year Peak Discharge (cubic feet per second or cfs)
Unnamed (Stream 27A)		
At mouth	0.14	510
Upstream Limit	0.06	230
Sagamea Stream		
At mouth	0.18	640
Papa Stream		
At mouth	0.86	2,290
Upstream limit	0.80	2,160
Mataali Stream		
At mouth	0.21	670
Upstream limit	0.18	580
Sauino Stream		
At mouth	0.33	1,010
Upstream limit	0.15	490
Vaitele Stream		
At mouth	4.00	5,020
Above confluence with Leaveave Drainageway	2.33	4,080
Above confluence with Taumata Stream	0.45	1,180
Above confluence with Unnamed Tributary	0.28	780
Leaveave Drainageway		
Above confluence with Vaitele Stream	1.59	2,920
10,500 feet above confluence with Vaitele Stream	0.70	1,560
Taumata Stream		
Above confluence with Vaitele Stream	1.86	3,580
1,000 feet above confluence with Taumata Stream	1.78	3,480
4,200 feet above confluence with Taumata Stream	1.61	3,270
Above confluence with Mapusagatuai Stream	1.17	2,590
Mapusagatuai Stream		
Above confluence with Taumata Stream	0.35	900
3,500 feet above confluence with Taumata Stream	0.13	360

Source: Federal Emergency Management Agency (FEMA), 1991

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding Along the Primary Shoreline Roadway

During at least the past 20 years, localized flooding has occurred on the east side of the Nuuuli Pala watershed following heavier rainfall events. Stormwater flows typically pond on the surface of the primary shoreline roadway. On some occasions, ponding along the roadway is also significant enough to generate some localized flooding in residential and commercial areas that are immediately adjacent to the primary roadway. These conditions typically generate some temporary driving hazards and related traffic congestion.

ASG Public Works crews are frequently dispatched to Nuuuli following heavier rainfall periods to remove ponded water on the roadway surface. Such maintenance efforts require a combination of tasks such as the clearing of blocked culverts, the pumping of stormwater into adjacent stream courses, and the clean-up of debris.

Using the results of stormwater modeling, hydraulic analyses, and a survey of existing culverts, PPC believes that localized flooding along portions of the primary shoreline roadway result from:

- some physical obstructions to culvert inlets and outlets;
- hardening and narrowing of streams at the inlet and outlet of some bridges and culverts;
- inadequate culvert sizes;
- debris and vegetation inside culverts that reduces culvert capacity; and,
- a general lack of regular culvert maintenance on a periodic basis.

Sedimentation

Pala Lagoon acts as a natural detention basin for surface runoff and sediments. A significant amount of sediment is discharged into Pala Lagoon. This sedimentation occurs particularly during and following storm events.

In its modeling of the six streams that discharge into Pala Lagoon, Pedersen Planning Consultants determined that a 2-year storm event generates a discharge of almost 160 tons of sediment in the lagoon. Roughly 500 tons of sediment are generated by a potential 100-year storm event (Table 2-4).

TABLE 2-4
SEDIMENT CONTRIBUTION TO PALA LAGOON
2,10, 50, AND 100-YEAR STORM EVENTS
IN TONS PER STORM EVENT

Stream	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Vaitele	82.6	134.0	228.2	256.9
Sauino	3.2	5.2	9.0	10.2
Mataalii	17.6	28.2	48.5	55.2
Papa	31.1	49.9	86.2	98.1
Sagamea	11.1	17.8	30.7	34.9
Stream 27A	13.3	21.3	36.7	41.8
All Streams	158.9	256.4	439.3	497.1

Source: Pedersen Planning Consultants

In 1980, Aecos and Aquatic Farms reported that the bottom of the inner Pala Lagoon contained mud and silty sand. These characteristics generally confirmed the past detention of sediments in the lagoon. Mud and silty sand probably continue to characterize the inner lagoon, but to a greater extent. It is suspected that a considerably greater amount of mud is now contained in the lagoon. The location of the Pago Pago International Airport runway system, which was constructed between 1959 and 1961, clearly altered water circulation, wave energy, and water exchange patterns that would otherwise reduce the amount of sediment and decomposed mud within the lagoon.

The source of sediments is derived from more erosive soils along the upper slopes of the Nuuuli Pala watershed. These include soils from the Fagasa family-Lithic Hapludolls-Rock Outcrop Association, as well as Aua very stony silty clay loam. Surface runoff carries eroded soil material into the six streams that discharge into Pala Lagoon.

The detention of surface runoff is needed to help reduce the amount of sediment that is discharged into Pala Lagoon via stormwater events. Potential detention areas in the lower watershed are limited. Most of the lower portions of the watershed are already urbanized by residential and commercial land uses.

Marine Resources and Related Water Quality

Pala Lagoon is a spawning ground for some fishes and invertebrates that characterize the nearshore waters. In the late 1970's, clams were intensively harvested on the intertidal mudflats that characterize the north and northwest parts of the lagoon (Aecos and Aquatic Farms, 1980).

In 1975, Helfrich noted that the presence of several small fishes, primarily mullet, that frequented the shallow waters of the lagoon. In 1980, Aecos and Aquatic Farms observed larvae of fish that resided in the inner lagoon, e.g., gobies, as well as fish that migrated in and out of the lagoon. In May, 1998, fish larvae were observed by Pedersen Planning Consultants along the west shoreline of the lagoon near the Vaitele Stream mouth.

Adequate water quality is needed to sustain and enhance the spawning ground for various fishes and invertebrates. In general, the periodic input of a considerable amount of sediments into an embayment, where natural water exchange is restricted, can significantly impact water quality. The long-term decomposition of sediments, in essence, can dramatically change the physical environment and water quality characteristics that are necessary to sustain invertebrates.

Unfortunately, the more recent biota and water quality of Pala Lagoon is not well known. Quantitative data of selected biological and water quality characteristics in the lagoon are needed to compare with biological characteristics observed in the mid to late 1970's, as well as document changes that have resulted from increased sedimentation, the decomposition of sediments, and a reduction of nutrient inputs.

Water Quality Standards

The water quality standards for American Samoa, which were most recently revised in 1989, identify Pala Lagoon as a "special embayment". This designation was primarily based upon:

- the spawning ground that characterizes the lagoon; and,
- the prior designation of the lagoon as a special management area by the American Samoa Coastal Management Program.

Surface water quality standards that are applicable to Pala Lagoon are summarized in Table 2-5.

TABLE 2-5
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO PALA LAGOON

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	0.75	NTU
Total Phosphorus	15.00	microngrams per liter
Total Nitrogen	135.00	microngrams per liter
Chlorophyll a	0.35	microngrams per liter
Dissolved Oxygen	Not less than 80% saturation or less than 5.5 mgl. If the natural level of DO is less than 5.5 mgl, the natural level shall be the standard.	milligrams per liter
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

In 1975, Helfrich reported chlorophyll a levels in Pala Lagoon that exceeded ASEPA water quality standards. The highest chlorophyll a levels were detected near the mouths of Vaitele Stream and Papa Stream.

More recently, a one-time sampling in early 1995 indicated total nitrogen levels and chlorophyll a levels that exceeded water quality standards. It is believed that this sampling was probably taken within the inner lagoon where greater silt is evident on the lagoon bottom and less water circulation occurs.

In the outer lagoon, water quality samples were made at depths of 3 and 25 feet in July and August, 1992. Nutrient and chlorophyll a levels that were measured from these samplings were well within ASEPA water quality standards. These measurements suggest that the water quality of the outer lagoon is influenced by greater water exchange and circulation.

STORMWATER MANAGEMENT FACILITIES

Between Vaitele and Amaile Stream, there are 13 culverts that permit the passage of stormwater runoff underneath the primary shoreline roadway in Nuuuli. These culverts include a variety of box and circular culverts that were constructed through the use of concrete, corrugated metal pipe, or basaltic rock.

Condition and Deficiencies

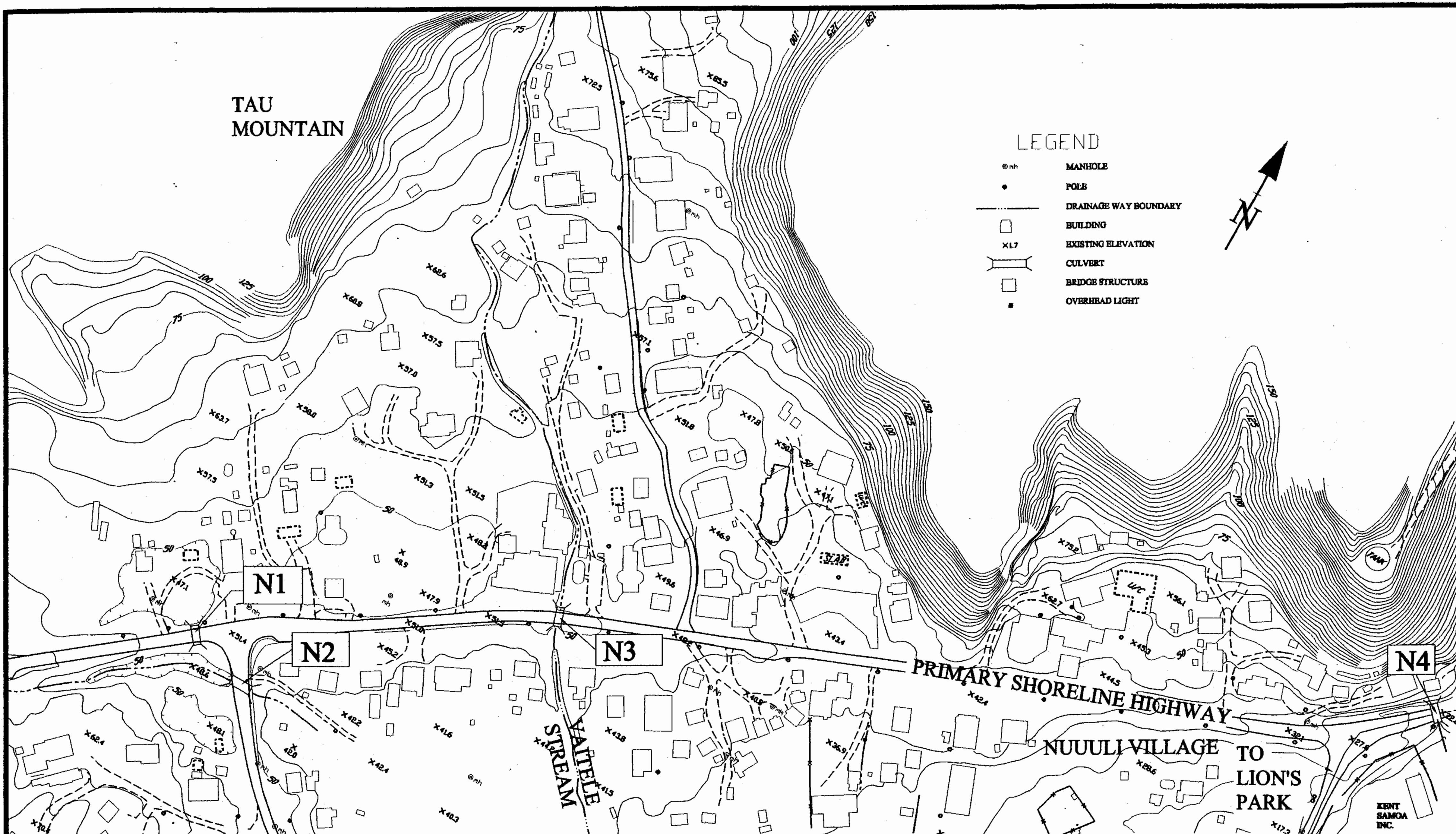
A field survey of the 13 culverts in May, 1998 revealed that existing culverts are generally in good structural condition. The physical deficiencies associated with each culvert are summarized in Table 2-6; culvert locations are presented in Figures 2-2 through 2-5.

These culverts frequently become clogged with debris and vegetation. Regular periodic maintenance is required to make effective use of the culverts and reduce flood potential.

TABLE 2-6
STORMWATER CULVERTS
CONDITIONS, DEFICIENCIES, AND RECOMMENDED IMPROVEMENTS
MAY, 1998

Culvert	Size (feet)	Type	Material	Condi-tion	Required Flow (cfs)	Deficiency	Needed Improvements	Estimated Cost ($)
N1	9x4	Box	Concrete	Good	94	Size, Vegetation	Install second 9x4 culvert	21,780
N2	13x7	Box	Concrete	Good	400	Size, Vegetation	Install second 13x7 culvert	38,725
N3	12x5	Box	Concrete	Good	105	Size, Vegetation	Install second 12x5 culvert	26,890
N4	3 (diameter)	Circular	Concrete	Good	100	Size, Vegetation	Install second 3D culvert	14,880
N5	2.5 (diameter)	Circular	CMP	Good	69	Size, Vegetation	Install two 12x4 box culverts	69,380
N6	7.5x3.3	Box	Concrete	Good	276	Size, Vegetation	Install 7x4 box culvert	21,730
N7	2 (diameter)	Circular	Concrete	Poor	276	Silt and vegetation	Check inverts for proper install & maintenance.	1,150
N8	Two 3-foot diameter	Circular	Concrete	Poor	308	Size, silt, vegetation	Install two 8x4 concrete box culverts	55,180
N9	Two 12x8	Box	Concrete	Good	1,213	Size	Install one 12x8 concrete box culvert	20,380
N10	3x2	Box	Basaltic Rock	Good	50	Size	Install one 3x2 concrete box culvert	11,800
N11	4x4	Box	Concrete	Good	250	Size	Install one 7x4 concrete box culvert	13,300
N12	2.5 (diameter)	Circular	CMP	Good	214	Size	Install two 8x4 concrete box culverts	31,100
N13	Two 10.5x7	Box	Concrete	Good	500	Silt and debris	Clean and raise adjacent banks, realign stream on inlet side	33,000

Source: Pedersen Planning Consultants, 1998



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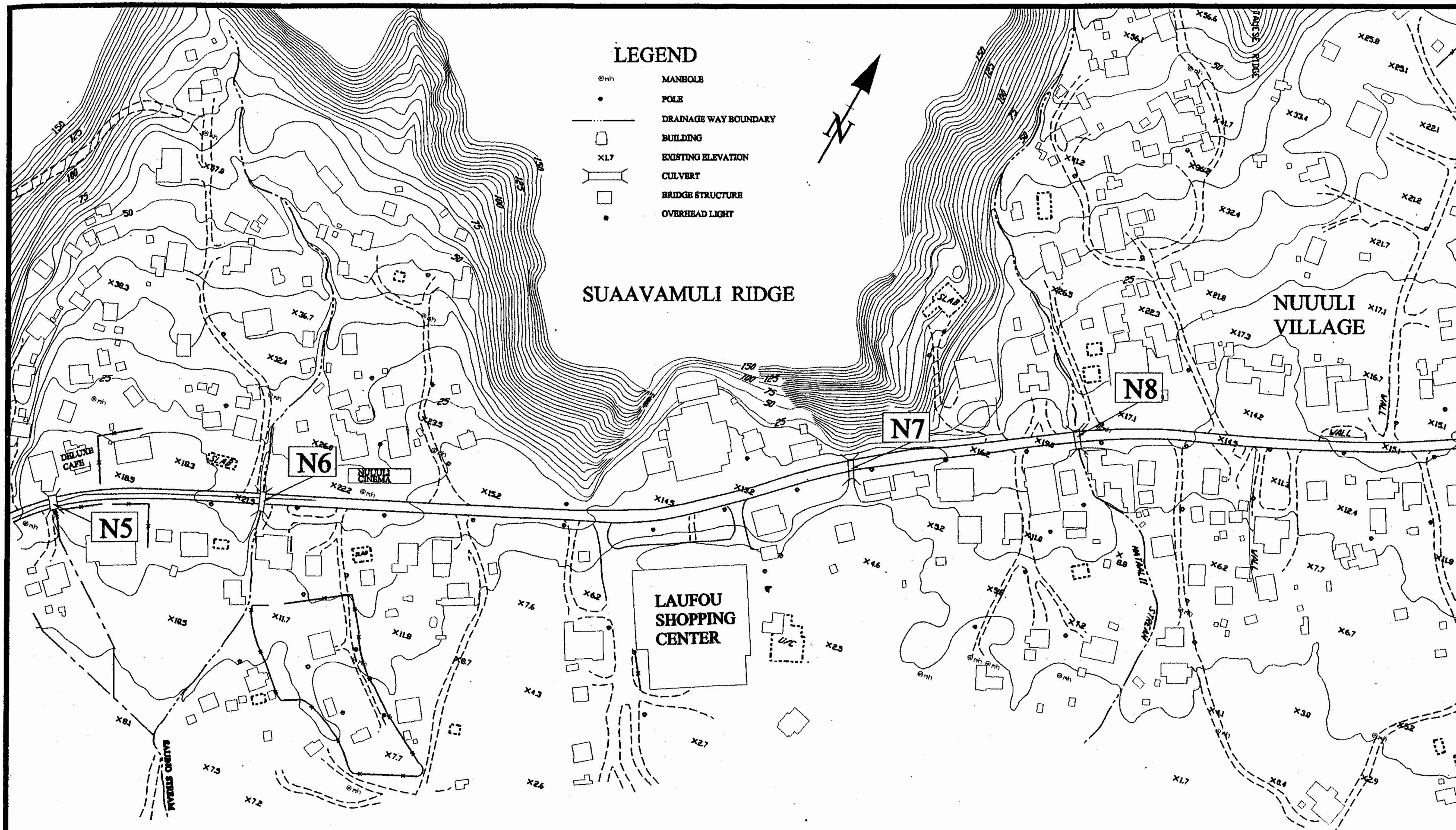
NUUULI STORMWATER MANAGEMENT FACILITIES ALONG PRIMARY SHORELINE ROADWAY

Scale: NOT TO SCALE

Figure 2-2



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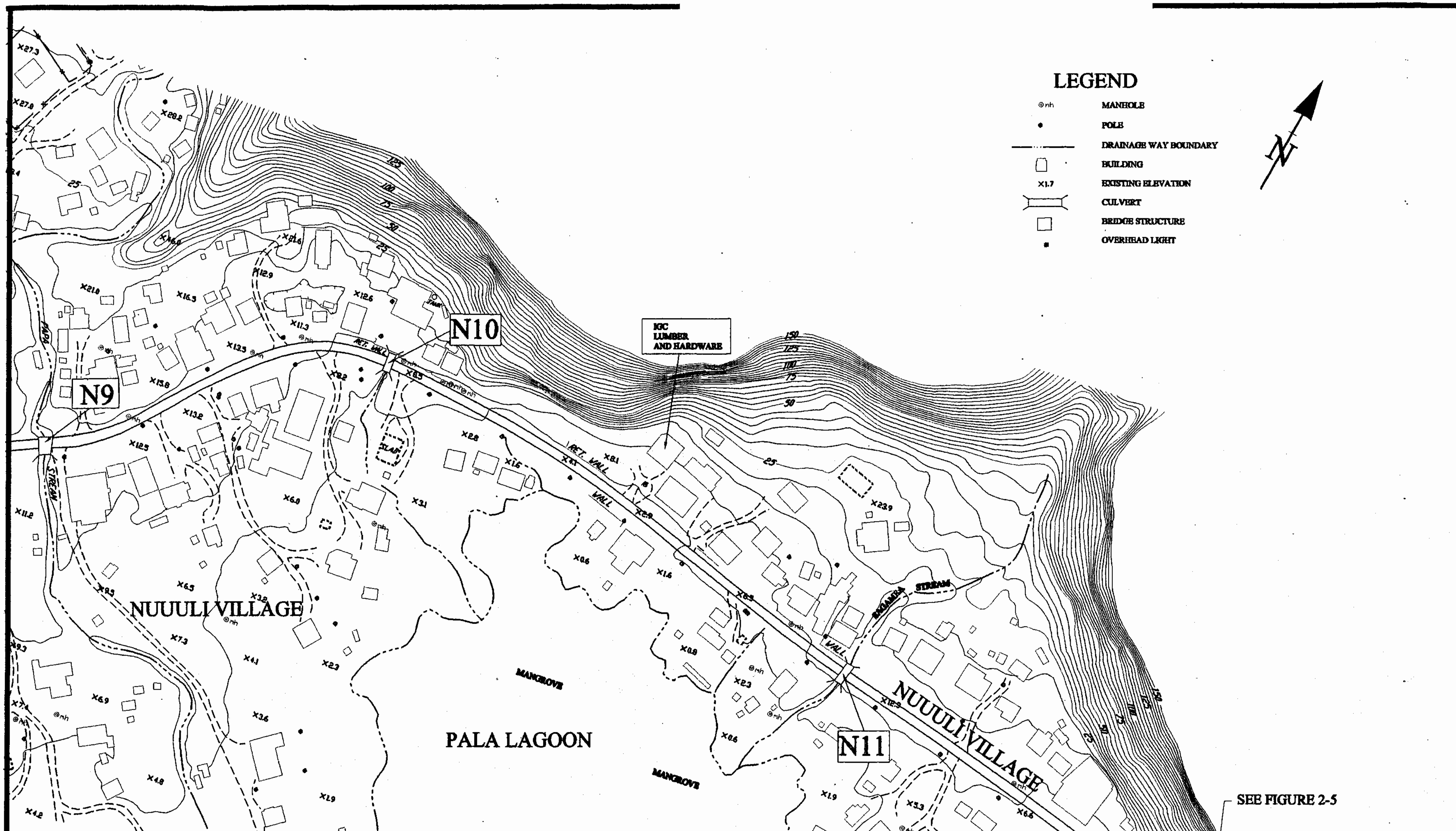
NUUULI STORMWATER MANAGEMENT FACILITIES
ALONG PRIMARY SHORELINE ROADWAY
Scale: NOT TO SCALE

Figure 2-3



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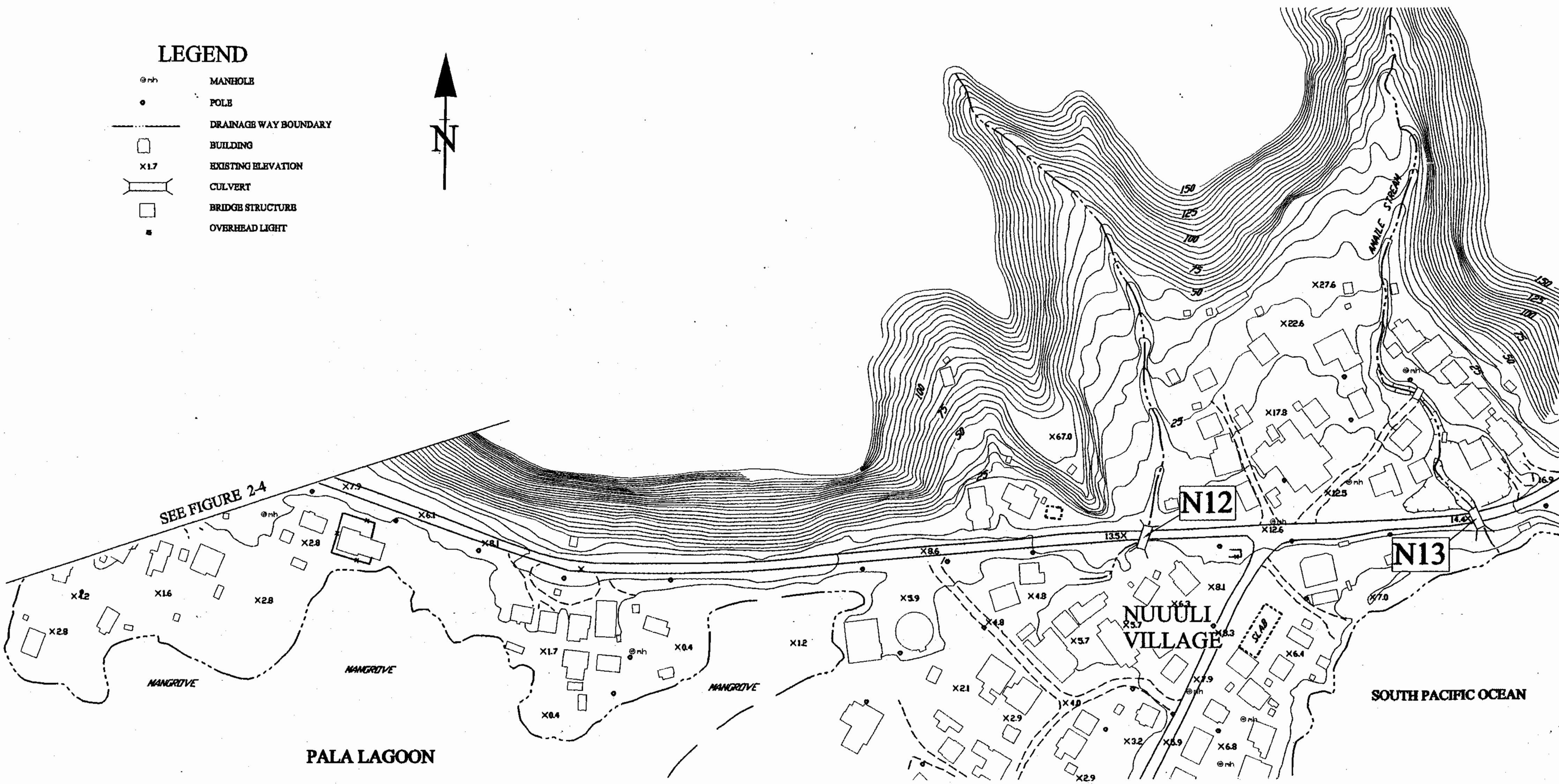
NUUULI STORMWATER MANAGEMENT FACILITIES ALONG PRIMARY SHORELINE ROADWAY

Scale: NOT TO SCALE

Figure 2-4



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NUUULI STORMWATER MANAGEMENT FACILITIES
ALONG PRIMARY SHORELINE ROADWAY

Scale: NOT TO SCALE

Figure 2-5

Recommended Facility Improvements and Estimated Costs

It is recommended that proposed improvements to stormwater culverts along the primary shoreline roadway, between Vaitele Stream and Amaile Stream, be constructed (Table 2-6). Some of the culverts are also somewhat undersized to accommodate higher stormwater flows. The addition of a second box culvert would permit, in some cases, the passage of greater stormwater flows underneath the primary shoreline roadway. The construction of additional culverts in some locations (Table 2-6) will increase facility capacity and reduce future flood potential along the primary shoreline roadway. However, in other locations, the bank outlet is narrower than the width of the existing culvert outlet.

The construction of stormwater culvert improvements is estimated to cost approximately $414,000. A more detailed breakdown of costs associated with recommended stormwater improvements are presented in Appendix A.

Recommended Maintenance of Stormwater Culverts

Regular periodic maintenance of each stormwater culvert between Vaitele Stream and Amaile Stream is required to reduce localized flooding and the number of emergency responses by public works personnel to clear blocked stormwater culverts.

It is recommended that a three-person crew be organized by the ASG Department of Public Works to maintain these culverts, at least, four times per year. This crew should remove vegetation, garbage, and other debris that reduce the flow of stormwater discharges into culvert inlets and outlets. Such maintenance should extend along each of the 13 stream courses approximately 50 feet upstream and 50 feet downstream of culvert inlets and outlets, as well as inside the culverts that pass underneath the roadway.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes that can be used to clear vegetation;
- sledge hammers, picks, shovels, and rakes that can be used to remove obstructions and debris from stream course areas immediately adjacent to culvert inlets and outlets;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose that can be used to clear debris inside closed culverts; and, small truck to haul collected solid waste material and garbage from each stream course and culvert.

STORMWATER DETENTION OPPORTUNITIES

Two potential sites offer some potential for stormwater detention opportunities (Figure 2-6):

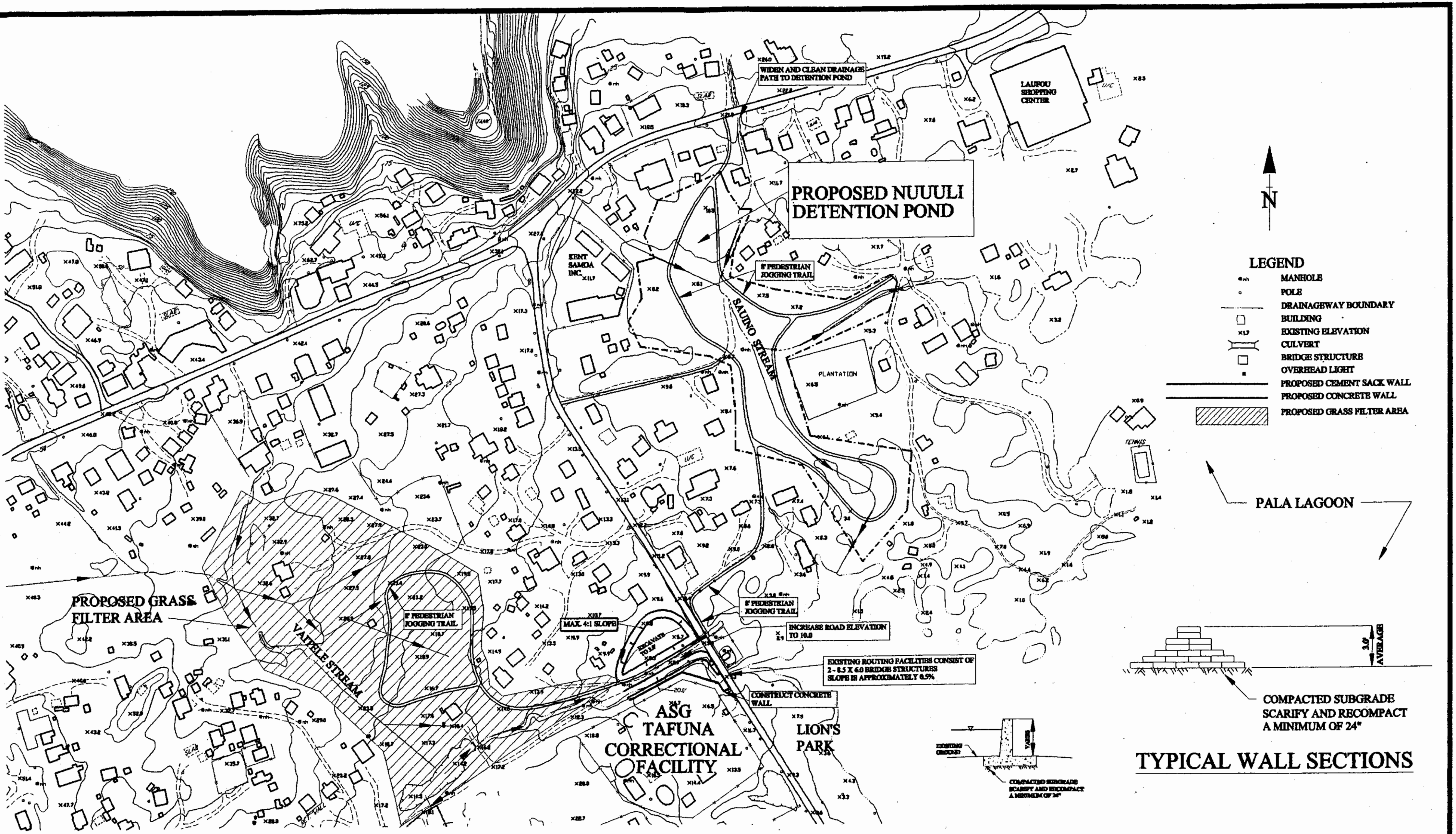
- the lower Sauino Stream drainage; and,
- the lower Vaitele Stream drainage.

Existing land uses, which are adjacent to other stream courses that discharge into Pala Lagoon, limit the amount of lands that could potentially be devoted to this purpose. Other potential areas represent well-developed mangrove swamps. Consequently, there are limited areas available for the development of potential stormwater detention facilities.

Lower Sauino Stream Drainage

Site Location

The lower Sauino Stream drainage passes underneath the primary shoreline roadway on the west side of the Nuuuli Cinema complex in Nuuuli. While much of the lower Sauino Stream drainage is already urbanized, a small undeveloped area lies seaward of the primary shoreline roadway and existing commercial facilities. A 9.1-acre area, which is situated immediately east of Kent Samoa, Inc., offers a potential stormwater detention opportunity (Figure 2-7).



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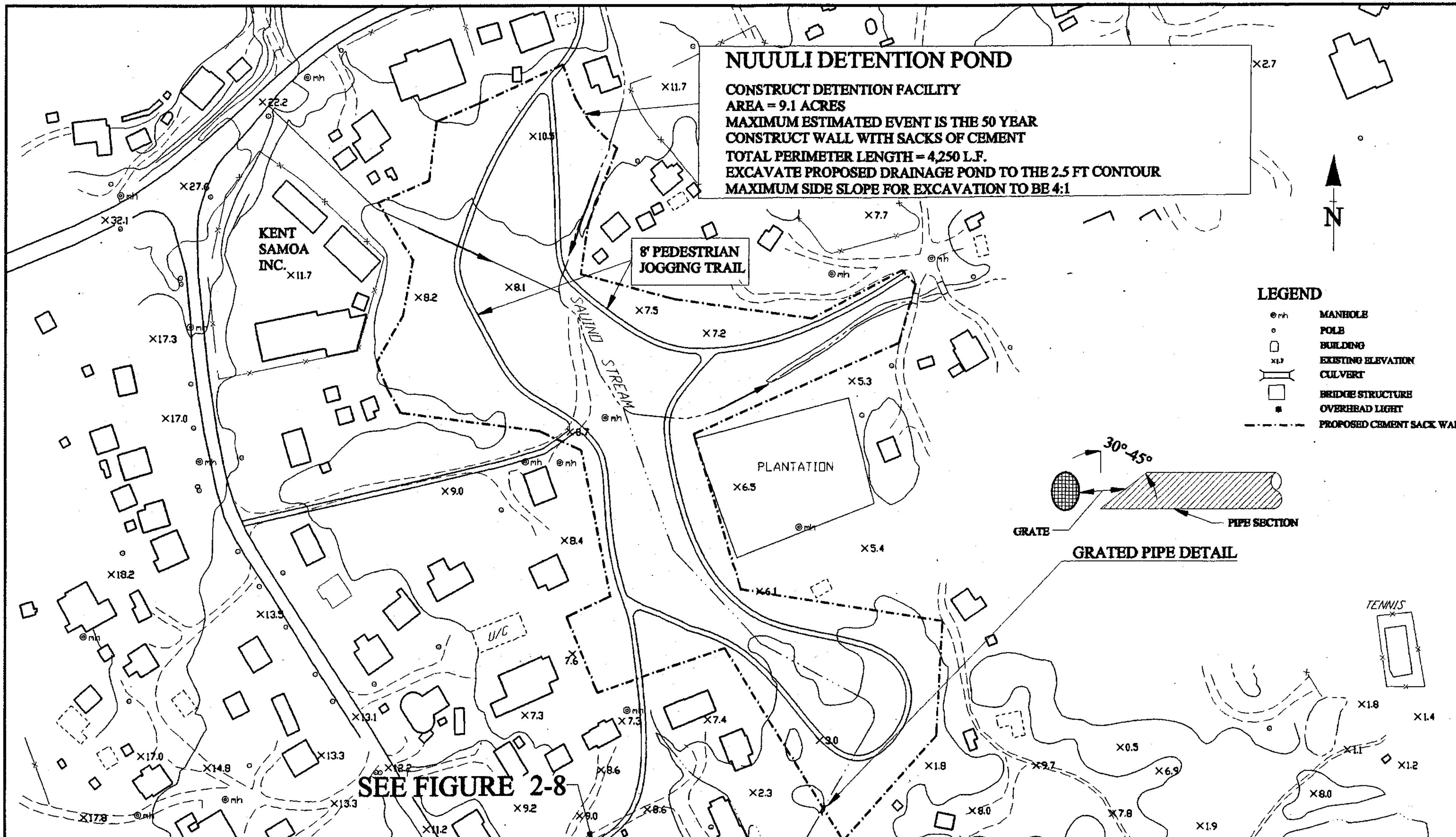
PROPOSED STORMWATER MANAGEMENT
LOWER SAUINO STREAM AND LOWER VAITELE STREAM

Scale: 1"=300'

Figure 2-6



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PROPOSED NUUULI DETENTION POND
LOWER SAUINO STREAM

Scale: 1"=300'

Figure 2-7

Available topographic maps from R.M. Towill Corporation provide 5-foot contour elevations for this area. These topographic maps, which are based upon 1989 or 1990 aerial photography, suggest that the 9.1-acre site is located between 7 and 8-feet above mean sea level.

General Design Concept

The proposed detention area (Figure 2-7) would be excavated to the 2.5-foot contour. Roughly five to six feet of soil would initially be excavated from the detention area.

A five to six-foot high wall would be constructed along the perimeter of the detention pond, which would extend approximately 4,250 feet. The wall would be constructed through the use of small bags of cement that would be hand-carried and placed along the pond perimeter. The maximum side slope of the wall would contain a 4:1 slope.

The wall would be back-filled with native soil to reduce the visual impact of the concrete bags. Selected landscape materials would be planted along the outside of the pond perimeter to further enhance the attractiveness of the detention area. It is envisioned that landscaping would be accomplished by ASEPA and ASCC Land Grant Program.

In order to increase project benefits to Nuuuli residents and the general public, the proposed detention area would be accessible for general recreation. Open area inside the detention pond would be available for general play. No playground equipment would be installed. However, several portable benches would be located in the area. A coral trail, which would accommodate jogging and pedestrian use, would also be designated within the detention pond and connect to sidewalks along the primary roadway that fronts Lion's Park and the ASG Tafuna Housing area.

During more significant stormwater events, the detention pond area would be closed for recreational use to afford percolation of stormwater flows, the deposition of sediments, and ensure greater public safety. A cleanup of garbage and other solid waste material that would also need to be made within the detention area immediately following significant stormwater events.

Project Development Costs

Construction of the detention pond would cost roughly $1.4 million (Table 2-7). Based upon information gained from local contractors in American Samoa, it is believed that roughly 85 percent of the construction cost would reflect the cost of excavation and the construction of the wall around the pond perimeter.

TABLE 2-7
ORDER-OF-MAGNITUDE COST ESTIMATE
CONSTRUCTION OF DETENTION POND
ALONG SAUINO STREAM

Item	Unit Cost	Quantity	Extension ($)
Clear, grub, and remove	Lump Sum	1	10,300
Excavate	$3.50/Cubic Yard	64,000	224,000
Construct perimeter wall (sacks of cement)	$195/Linear Foot	4,750	926,250
Construct outlets	$3,500/Each	2	7,000
Construct coral pedestrian trail	$5/Linear Foot	4,250	21,250
		Subtotal	*$1,188,800*
		15% Contingency	*178,320*
		TOTAL	**$1,367,120**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

If constructed, a detention pond facility in this area could provide some nominal reduction in the amount of sediment that otherwise would be discharged into Pala Lagoon (Table 2-8). Roughly five tons of sediment could be detained from a 2-year storm event. Some 22 tons of sediment would be detained from a 100-year storm event.

TABLE 2-8
POTENTIAL SEDIMENT RETENTION
ACHIEVED VIA CONSTRUCTION OF DETENTION POND
ALONG SAUINO STREAM
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
5	9	17	22

Source: Pedersen Planning Consultants, 1999

Recreational opportunities in the Nuuuli area would also be increased with the development of a combination pedestrian and jogging trail within the detention pond. Public use of the trail would be encouraged by providing logical connections to nearby trails and sidewalks. These connections enable a continuation of the pedestrian and jogging trail to the Lower Vaitele Stream drainage where other stormwater management improvements are proposed. When combined with existing sidewalks, this pedestrian/jogging trail represents a significant recreational opportunity for residents of all ages, as well as a logical extension to other active recreational uses in Lion's Park.

Lower Vaitele Stream Drainage

Site Location

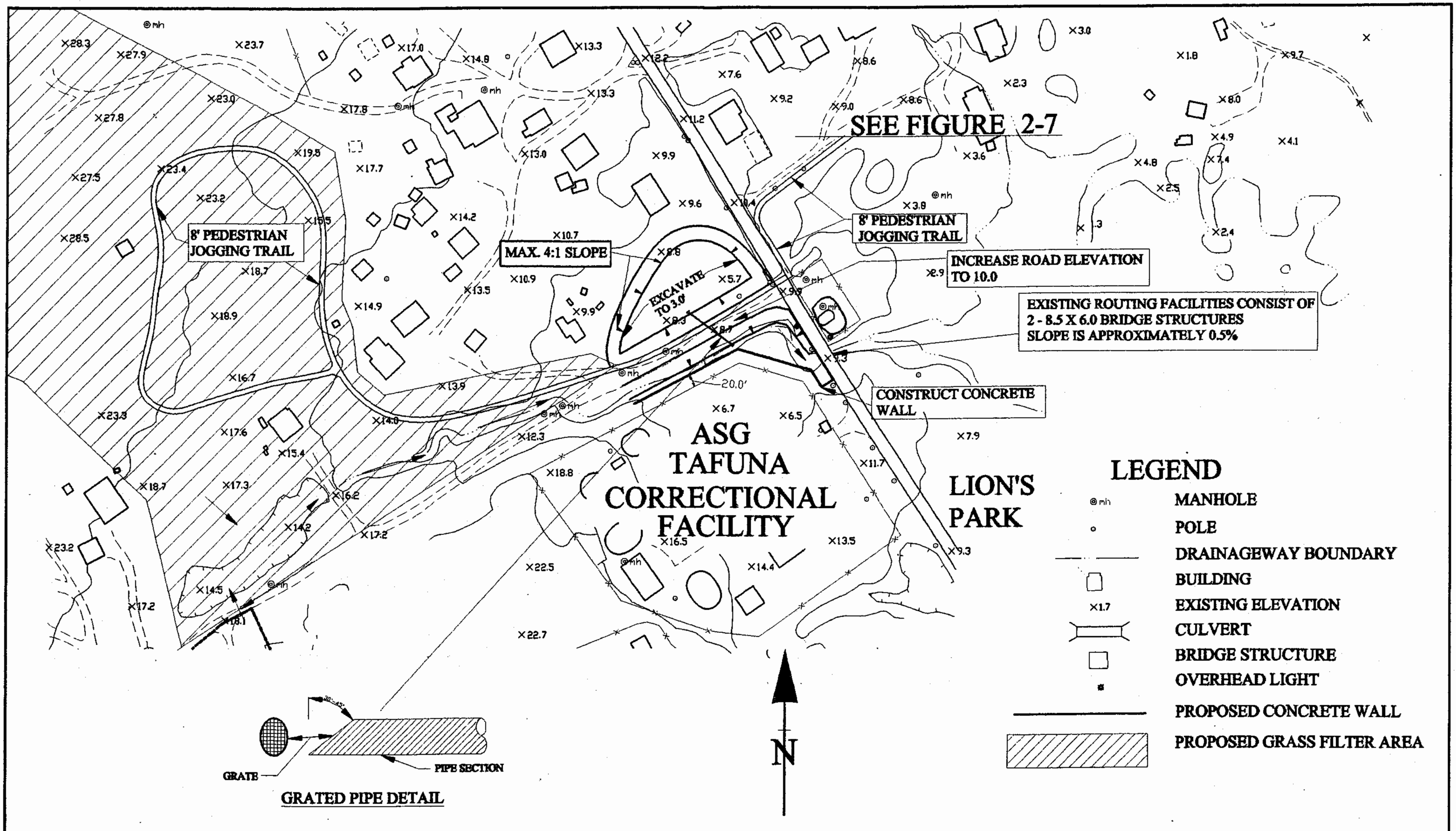
The lower Vaitele Stream drainage is located south of the primary shoreline roadway and northwest of the American Samoa Government Tafuna Correctional Facility and Lion's Park (Figure 2-6). This area primarily contains residential land uses. Some commercial banana production is also made in this area.

Prior to its final discharge on the north side of the ASG Tafuna Correctional Facility, Vaitele Stream meanders through a rocky stream course that contains a considerable amount of California grass and other weedy vegetation. Portions of the lower Vaitele Stream drainage contain a rather undefined stream channel. In this area, the construction and maintenance of a grass filter may be useful to help reduce sediment discharges into Pala Lagoon from lower stormwater flows.

General Design Concept

Several man-made swales from the defined Vaitele Stream course would be constructed to spread out future stormwater flows (Figures 2-6 and 2-8). Each swale would be approximately one-foot deep and 2 feet wide. The swales, which would extend some 100 to 200 feet in length, would be directed toward a grass filter area that would enable some filtering of sediments from lower stormwater flows.

The grass filter would make use of California grass or other vegetative cover. The grass would be maintained on a monthly basis; the height of the vegetative material would not be permitted to grow beyond two feet in height. Sediment trapped by the filter would need to be removed approximately once every three months.



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PROPOSED STORMWATER MANAGEMENT
LOWER VAITELE STREAM

Scale: 1"=300'

Figure 2-8

Some limited stormwater detention of lower stormwater flows could be achieved with a small depression northwest of the ASG Tafuna Correctional Facility. A second small detention area could be constructed immediately north of the Correctional Facility for the same purpose.

The construction of a new concrete wall along the perimeter of the Correctional Facility complex would also help move stormwater flows to the Vaitele Stream mouth more effectively. The wall would also help minimize some soil erosion that was evident near the northeast corner of the Correctional Facility complex in May, 1998.

The existing concrete culverts underneath the primary roadway (T1 and T2), which fronts Lion's Park and the ASG Tafuna Correctional Facility, as well as an allowable headwater of 13.9 feet, will accommodate an estimated stormwater flow of 1,580 cfs. The desired 13.9-foot height is considerably higher than the elevation of the existing road. In order to accommodate estimated stormwater runoff for a 100-year storm (with the same headwater), the installation of an additional double 12 x 9-foot culvert should be added at Culvert T1.

A proposed pedestrian/jogging trail would also be constructed within the proposed grass filter area to provide some recreational opportunities to residents of Nuuuli and the ASG Tafuna Housing area, as well as other island residents using the nearby Lion's Park.

Project Costs

Order-of-magnitude costs for the construction of grassed swales and a grass filter are estimated to be $15,600 (Table 2-9). The cost of constructing a concrete walls, the clearing and excavation of small depressions on the north side of the correctional facility, and the installation of a double 12 x 9-foot culvert, will require an expenditure of roughly $50,000 (Table 2-9).

TABLE 2-9
ORDER-OF-MAGNITUDE COSTS
CONSTRUCTION OF STORMWATER MANAGEMENT FACILITIES
LOWER VAITELE STREAM DRAINAGE

Item	Unit Cost	Quantity	Extension ($)
Swales	$3/Linear Foot	1,200	3,600
Coral pedestrian trail	$5/Linear Foot	2,000	10,000
Double 12x9 culvert	Lump Sum	1	50,000
		Subtotal	*$63,600*
		15% Contingency	*9,540*
		TOTAL	**$73,140**

Source: Pedersen Planning Consultants, 1999

In terms of long-term operation and maintenance, some consideration should be given to the use of Correctional Facility inmates. This labor could easily be moved to the project site and supervised by correctional facility personnel. Such labor could be supported by hand tools and other equipment from the ASG Department of Public Works.

Potential Project Benefits

The amount of sediment retention that is achieved through the use of a grass filter is dependent upon the amount of grass available at the time of contact with stormwater. The filter slows lower and medium stormwater flows and permits the settlement of sediments. Flatter ground slopes increase the effectiveness of the grass filter. Lands are sometimes terraced to increase the amount of flatter land area.

In consideration of site topography and anticipated stormwater runoff for 2, 10, 50, and 100-year storm events, it is estimated that the grass filter will make a nominal reduction in the amount of sediment discharge into Pala Lagoon (Table 2-10).

TABLE 2-10
POTENTIAL SEDIMENT RETENTION
ACHIEVED VIA CONSTRUCTION OF GRASS FILTER
ALONG LOWER VAITELE STREAM
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
7	10.5	16.8	18.8

Source: Pedersen Planning Consultants, 1999

Recreational opportunities in the Nuuuli area would also be increased with the development of a combination pedestrian and jogging trail around the grass filter. Public use of the trail would be encouraged by providing logical connections to nearby sidewalks. These connections enable a continuation of the pedestrian and jogging trail to lower Sauino Stream drainage where other stormwater management improvements are proposed. When combined with existing sidewalks, this pedestrian/jogging trail represents a significant recreational opportunity for residents of all ages, as well as a logical extension to other active recreational uses in Lion's Park.

CHAPTER THREE
DANIEL INOUYE INDUSTRIAL PARK

STUDY AREA LOCATION

Senator Daniel Inouye Industrial Park is located north of Pago Pago International Airport in Tafuna (Figure 3-1). The Industrial Park was initially developed by the Territory of American Samoa in the early 1960's to promote the establishment of industrial enterprises that would generate new sources of local employment.

STUDY OBJECTIVE

This stormwater evaluation focused upon stormwater runoff within the Industrial Park that ultimately drains along the north side of Pago Pago International Airport into Pala Lagoon. Opportunities for improving the management of stormwater flows were examined to:

- reduce future flooding and potential property damage within the Park; and,
- enhance the long-term water quality of Pala Lagoon.

HYDROLOGY

General Drainage Characteristics

Daniel Inouye Industrial Park contains approximately 100-acre areas of land area. Land contours within the Industrial Park generally range between approximately 10 and 40 feet above mean sea level. The topography is relatively flat; ground slopes range between one and two percent.

Surface runoff within the Industrial Park is routed along paved roadways and over land to specific outlets. Figure 3-2 depicts the direction of existing surface drainage in three drainage areas.

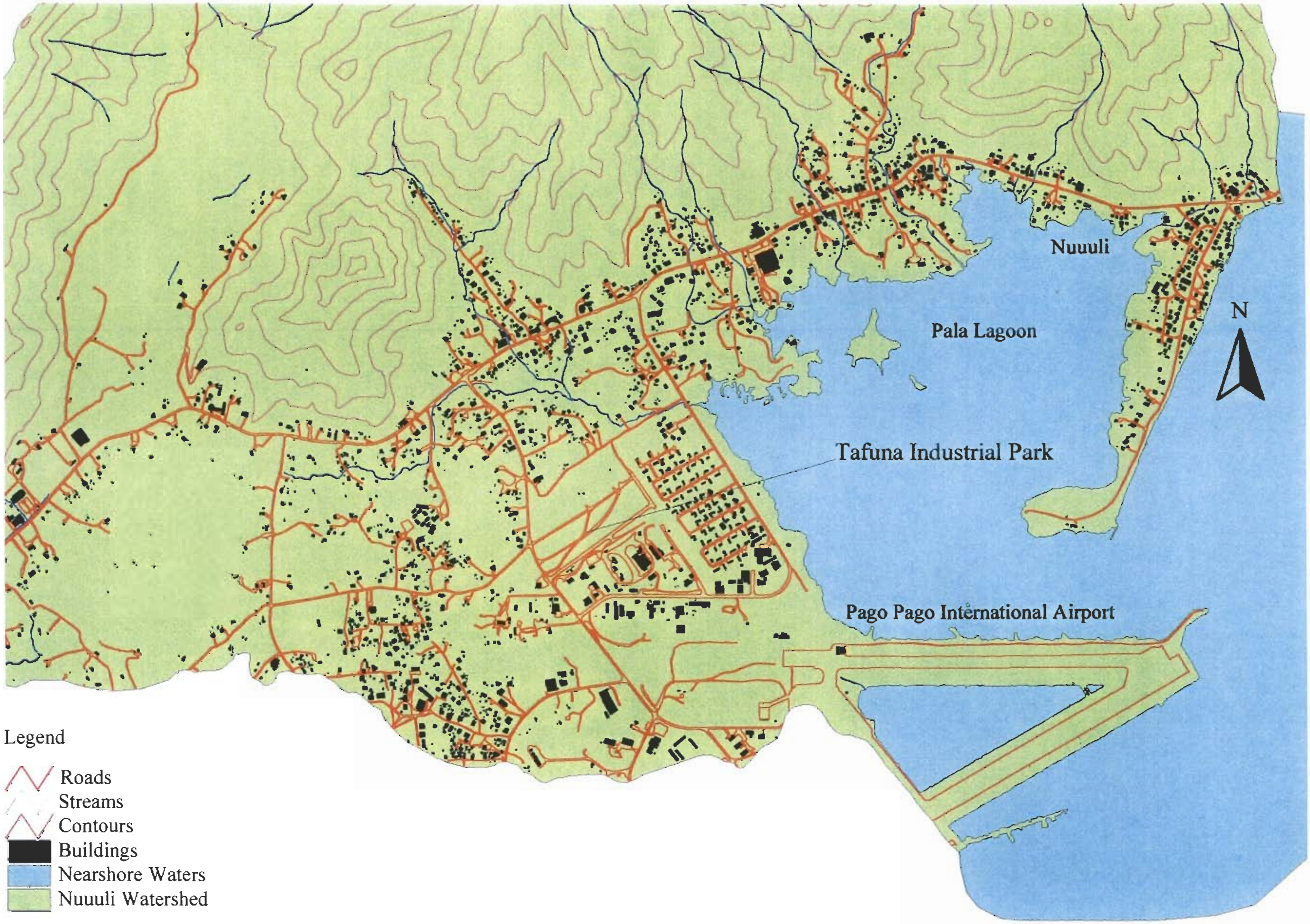
Area 1

The paved road fronting the BCTC Garment complex (Road A) drains northeast to a ditch on the east boundary of the Industrial Park. The ditch separates the Industrial Park from the adjacent ASG Tafuna Housing area. Curbs, gutters and storm drain inlets carry runoff to the ditch. Field observations suggest that stormwater flows in the ditch move northwest into the lower Vaitele Stream drainage. However, no vertical elevations were made in the ditch to confirm this drainage pattern.

Effective drainage in the ditch on the east side of Industrial Park is significantly constrained by a significant amount of California grass and solid waste material in the ditch. The roadway adjoining the ditch is also a popular nighttime gathering place for consuming alcoholic beverages. The disposal of bottles and cans into the ditch and adjoining roadway was evident in May, 1998. While some periodic maintenance is made by the ASG Department of Public Works, it is suspected that elevations in the ditch are considerably variable and do not permit efficient drainage.

Area 2

In Area 2, the paved road (Road B) that fronts Boral Energy, Samoa Maritime, and other commercial and light industrial services carries surface runoff from west to east. Curbs and gutters along the roadway carry stormwater runoff to storm drain inlets in the vicinity of the American Samoa Bank. Surface runoff from the inlets is discharged into a small ditch that carries stormwater runoff into the southwest part of Pala Lagoon.



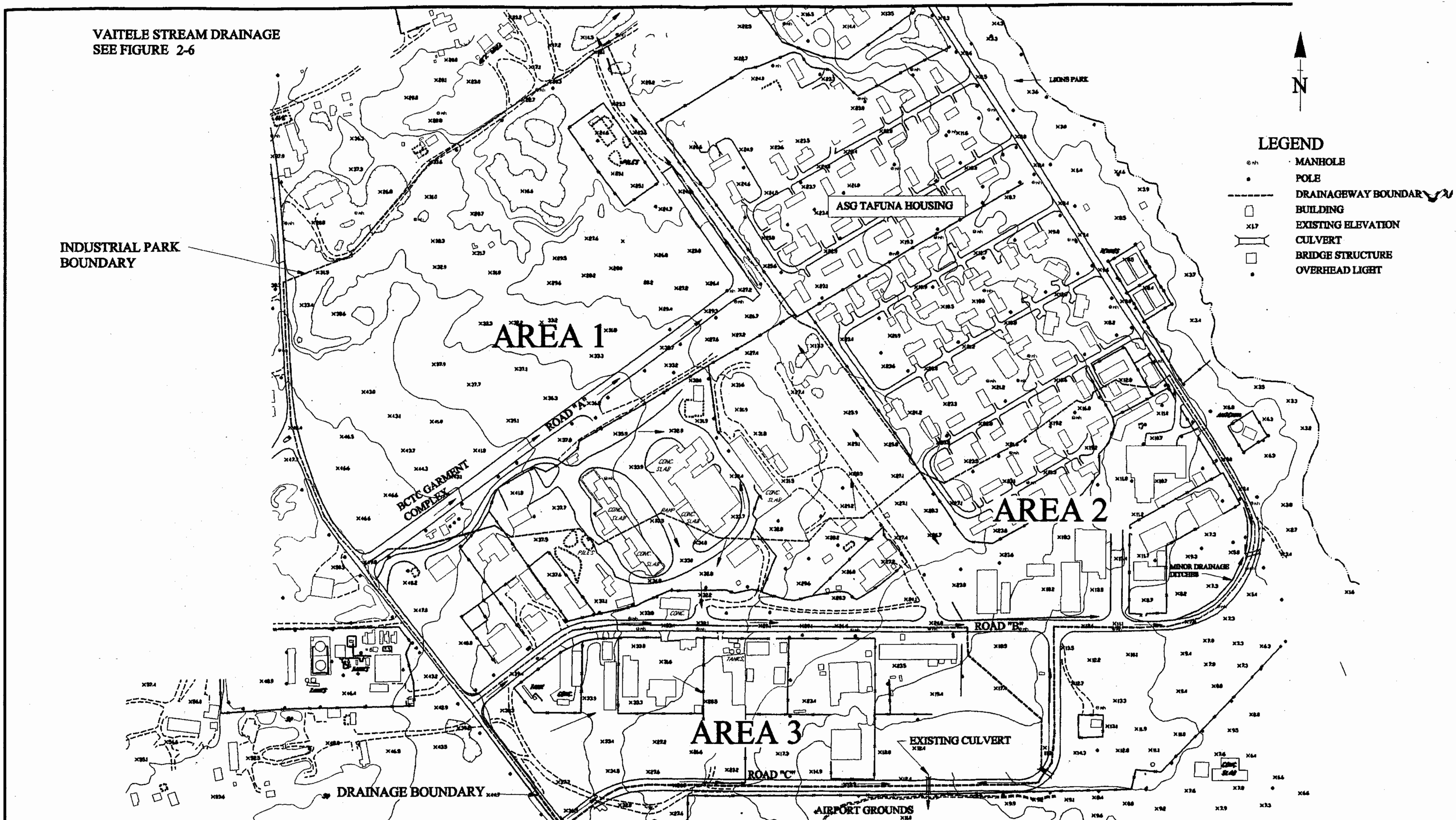
American Samoa Geographical Information System

Not to Scale

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Tafuna Industrial Park
Location Map

Figure 3-1



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DANIEL INOUYE INDUSTRIAL PARK
EXISTING STORMWATER MANAGEMENT

Scale: 1" = 300'

Figure 3-2

Area 3

Curbs and gutters along Road C, as well as overland flow, transport surface runoff from west to east. An existing culvert and drainage ditch near the southeast corner of Drainage Area 3 carries drainage to the north part of the Pago Pago International Airport property. A poorly defined drainageway in this area transports stormwater runoff to the southwest part of Pala Lagoon.

Stream Flows

There are no streams in the Industrial Park.

Stormwater Runoff

Heavier rainfall events generate stormwater runoff within the Daniel Inouye Industrial Park. These flows primarily discharge into the lower Vaitele Stream drainage and the southwest part of Pala Lagoon. The remaining flow likely percolates into the substrata associated with the ditch on the east side of the Industrial Park, as well as the ditches south of the American Samoa Bank, and the north side of Pago Pago International Airport.

Stormwater flows within the Daniel Inouye Industrial Park have increased considerably since the initial construction of the Industrial Park in the 1960's. The development of hardened surfaces such as paved roads, vehicular parking areas, compacted ground surfaces, as well as new commercial and industrial facilities have generated this increase.

Computer modeling of Industrial Park drainage by Pedersen Planning Consultants suggests potential stormwater flows that range between 110 cubic feet per second (cfs) for a 2-year storm event and 453 cfs for a 100-year storm (Table 3-1). Roughly half of the potential stormwater flows discharge into the lower Vaitele Stream drainage; the remainder discharge into Pala Lagoon.

TABLE 3-1
DANIEL INOUYE INDUSTRIAL PARK
STORMWATER RUNOFF DISCHARGES
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Drainage	Area (acres)	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Area 1	50	58.3	100.0	188.6	224.2
Area 2	32	35.2	62.0	121.7	147.4
Area 3	17	17.3	31.6	65.5	81.4
All	**99**	**110.8**	**193.6**	**375.8**	**453.0**

Source: Pedersen Planning Consultants, 1998

Correlation With Other Stormwater Runoff Estimates

A flood insurance study was published by the Federal Emergency Management Agency (FEMA) in May, 1991. This study included flood risk data for selected areas on the Island of Tutuila that were intended to:

- facilitate the establishment of actuarial flood insurance rates; as well as,
- provide information that could be used for local floodplain management efforts in American Samoa.

In 1987, the U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses for the drainageway on the north side of Pago Pago International Airport that supported the FEMA study. A 0.37-square mile drainage area was identified by the Corps of Engineers that included stormwater flows from the Industrial Park, as well as the east part of Tafuna. A 100-year peak discharge of 540 cfs was calculated for the 0.37 square mile drainage area.

The stormwater modeling approaches used by the U.S. Army Corps of Engineers and PPC varied somewhat. However, the correlation of estimated stormwater discharges for a 100-year storm event suggest that the stormwater flows from the Industrial Park represent a minor portion of the total stormwater discharges into the southwest part of Pala Lagoon.

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding Within the Industrial Park

Localized flooding occurs within portions of the Daniel Inouye Industrial Park during and following periods of heavier rainfall. Intermittent observations made by Pedersen Planning Consultants during the 1995-1998 period suggest that flooding primarily occurs on the east end of Road B in the vicinity of the American Samoa Bank. As stated earlier, drainage on the east side of Road B is derived from surface runoff from Drainage Area 2.

Occasional flooding along the east side of Road B typically generates some temporary driving hazards and related traffic congestion. It is unknown whether or not this flooding has caused any property damage to adjacent facilities on the north side of Road B such as the American Samoa Bank building.

ASG Public Works crews are occasionally dispatched to the east side of Road B following heavier rainfall periods to remove ponded water on the roadway surface. Such maintenance efforts require a combination of tasks such as the clearing of blocked culverts, the pumping of stormwater into adjacent drainage ditches, and the clean-up of debris.

Using the results of stormwater modeling, hydraulic analyses, and a survey of existing culverts, PPC believes that localized flooding on the east side of Road B results from:

- some physical obstructions to culvert inlets and outlets;
- inadequate culvert sizes;
- debris and vegetation inside culverts that reduces culvert capacity; and,
- a general lack of regular culvert maintenance on a periodic basis.

Sedimentation

A significant amount of sediment is discharged into Pala Lagoon. Sediments are primarily derived via surface runoff from six streams on the north and west sides of Lagoon (see Chapter 2). Some additional sediments from the Daniel Inouye Industrial Park are discharged into Pala Lagoon via the drainage ditches on the south side of Lion's Park, the north side of Pago Pago International Airport, and the lower Vaitele Stream drainage.

In its modeling of the six streams that discharge into Pala Lagoon, Pedersen Planning Consultants determined that a 2-year storm event generates a discharge of almost 160 tons of sediment in the lagoon. Roughly 500 tons of sediment are generated by a potential 100-year storm event.

TABLE 3-2
SEDIMENT CONTRIBUTION TO PALA LAGOON
FROM DANIELD INOUYE INDUSTRIAL PARK
2,10, 50, AND 100-YEAR STORM EVENTS
IN TONS PER STORM EVENT

Drainage Area	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Area 1	1.8	3.3	6.7	8.2
Area 2	2.6	4.5	9.5	19.0
Area 3	1.0	1.9	4.2	5.3
All Streams	**5.4**	**9.7**	**20.4**	**22.5**

Source: Pedersen Planning Consultants, 1999

Daniel Inouye Industrial Park is characterized by soils classified as Tafuna extremely stony muck (SCS soil mapping unit 32) and Troporthents (SCS soil mapping unit 33).

Tafuna extremely stony muck, which characterizes the northern two-thirds of Drainage Area 1, has a slight potential for soil erosion. The southern one-third of Drainage Area 1 and all of Drainage Areas 2 and 3 contain Troporthents soils that contain little organic matter as this soil primarily consists of cobbles, sand, gravel. For this reason, the sediment contribution is limited when compared to other stream discharges into Pala Lagoon.

In 1980, Aecos and Aquatic Farms reported that the bottom of the inner Pala Lagoon contained mud and silty sand. These characteristics generally confirmed the past detention of sediments in the lagoon. Mud and silty sand probably continue to characterize the inner lagoon, but to a greater extent. It is suspected that a considerably greater amount of decomposed organic material is now contained in the lagoon. The location of the Pago Pago International Airport runway system, which was constructed between 1959 and 1961, clearly altered water circulation, wave energy, and water exchange patterns that would otherwise reduce the amount of sediment and decomposed mud within the lagoon.

Marine Resources and Related Water Quality

Pala Lagoon is a spawning ground for some fishes and invertebrates that characterize the nearshore waters. In the late 1970's, clams were intensively harvested on the intertidal mudflats that characterize the north and northwest parts of the lagoon (Aecos and Aquatic Farms, 1980).

In 1975, Helfrich noted the presence of several small fishes, primarily mullet, frequenting the shallow waters of the lagoon. In 1980, Aecos and Aquatic Farms observed larvae of fish that resided in the inner lagoon, e.g., gobies, as well as fish that migrated in and out of the lagoon. In May, 1998, fish larvae were observed by Pedersen Planning Consultants along the west shoreline of the lagoon near the Vaitele Stream mouth.

Adequate water quality is needed to sustain and enhance the spawning ground for various fishes and invertebrates. In general, the periodic input of a considerable amount of sediments into an embayment, where natural water exchange is restricted, can significantly impact water quality. The long-term decomposition of sediments, in essence, can dramatically change the physical environment and water quality characteristics that are necessary to sustain invertebrates.

Unfortunately, the more recent biota and water quality of Pala Lagoon is not well known. Quantitative data of selected biological and water quality characteristics in the lagoon are needed to compare with biological characteristics observed in the mid to late 1970's, as well as document changes that have resulted from increased sedimentation, the decomposition of sediments, and a reduction of nutrient inputs.

Water Quality Standards

The water quality standards for American Samoa, which were most recently revised in 1989, identify Pala Lagoon as a "special embayment". This designation was primarily based upon:

- the spawning ground that characterizes the lagoon; and,
- the prior designation of the lagoon as a special management area by the American Samoa Coastal Management Program.

Surface water quality standards that are applicable to Pala Lagoon are summarized in Table 3-3.

TABLE 3-3
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO PALA LAGOON

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	0.75	NTU
Total Phosphorus	15.00	microngrams per liter
Total Nitrogen	135.00	microngrams per liter
Chlorophyll a	0.35	microngrams per liter
Dissolved Oxygen	Not less than 80% saturation or less than 5.5 mgl. If the natural level of DO is less than 5.5 mgl, the natural level shall be the standard.	milligrams per liter
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

In 1975, Helfrich reported chlorophyll a levels in Pala Lagoon that exceeded ASEPA water quality standards. The highest chlorophyll a levels were detected near the mouths of Vaitele Stream and Papa Stream. Higher nutrient levels were also documented on the west side of Pala Lagoon.

More recently, a one-time sampling in early 1995 indicated total nitrogen levels and chlorophyll a levels that exceeded water quality standards. It is believed that this sampling was probably taken within the inner lagoon where greater silt is evident on the lagoon bottom and less water circulation occurs.

In the outer lagoon, water quality samples were made at depths of 3 and 60 feet in July and August, 1992. Nutrient and chlorophyll a levels that were measured from these samplings were well within ASEPA water quality standards. These measurements suggest that the water quality of the outer lagoon is influenced by greater water exchange and circulation. Consequently, limited sediment discharges from drainage ditches on the south side of Lion's Park and the north part of Pago Pago International Airport may have little impact upon the water quality of Pala Lagoon.

STORMWATER MANAGEMENT FACILITIES

Condition and Deficiencies

Storm Drains

There are several storm drain inlets within the Industrial Park. Concrete storm drain inlets were constructed at selected points along Road A. Road drainage is directed to the inlets via concrete curbs and gutters.

One of the more important storm drain inlets is located along the east end of Road B. Drainage into this storm drain passes through a culvert before entering a ditch on the south side of Lion's Park.

Stormwater inlets appeared to be in generally good condition in May, 1998. However, more frequent stormwater flows, e.g., 2-year storm, within the Industrial Park occasionally transport debris that may temporarily clog a given storm drain inlet and hamper drainage within the Industrial Park. Periodic maintenance of the inlets is needed to minimize the clogging of stormwater inlets.

Stormwater Culverts

A stormwater culvert, which passes underneath Road C, directs road drainage and stormwater flows to the north side of Pago Pago International Airport. This box culvert was constructed with concrete and is approximately 4 x 2 feet in size. In May, 1998, this culvert appeared to be in good structural condition. However, tall California grass and some garbage was evident past the outlet of the culvert.

Drainageways and Ditches

The capacity of the unlined drainage ditch located on the east side of the Industrial Park is hampered by the presence of garbage and vegetation that obstruct storm drainage flows. The presence of debris and inadequate slope results in this ditch serving primarily as a holding pond. Otherwise, the ditch represents a logical potential route for the drainage of stormwater flows from Drainage Area 1.

The unlined ditches and drainageways south of Lion's Park and the north side of the Pago Pago International Airport are not well-defined and do not enable an efficient drainage of stormwater flows to Pala Lagoon. A well-defined drainage route is needed in both areas to ensure efficient drainage of stormwater flows from Drainage Areas 2 and 3.

Recommended Facility Improvements

Periodic Maintenance of Storm Drains and Culverts

Storm drains and culverts in the Industrial Park should be periodically maintained to permit the effective transport of stormwater runoff to downstream drainageways (Figure 3-3). Otherwise, localized flooding in selected areas of the Industrial Park will continue.

It is recommended that a three-person crew be organized by the ASG Department of Public Works to maintain storm drains and culverts, at least, four times per year. This crew should remove vegetation, garbage, and other debris that reduce the flow of stormwater discharges inside storm drains and culverts. The maintenance of culverts should also extend approximately 50 feet upstream and downstream of all culverts.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes to clear vegetation;
- sledge hammers, picks, shovels, and rakes for the removal of obstructions and debris from storm drains and culverts;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose to clear debris inside storm drains and culverts; and,
- small truck to haul collected solid waste material from each storm drain and culvert.

Some of the culverts are also somewhat undersized to accommodate higher stormwater flows. The addition of a second box culvert in most cases would effectively enable the passage of greater stormwater flows underneath the primary shoreline roadway. The construction of additional culverts will increase facility capacity and reduce future flood potential along the primary shoreline roadway.

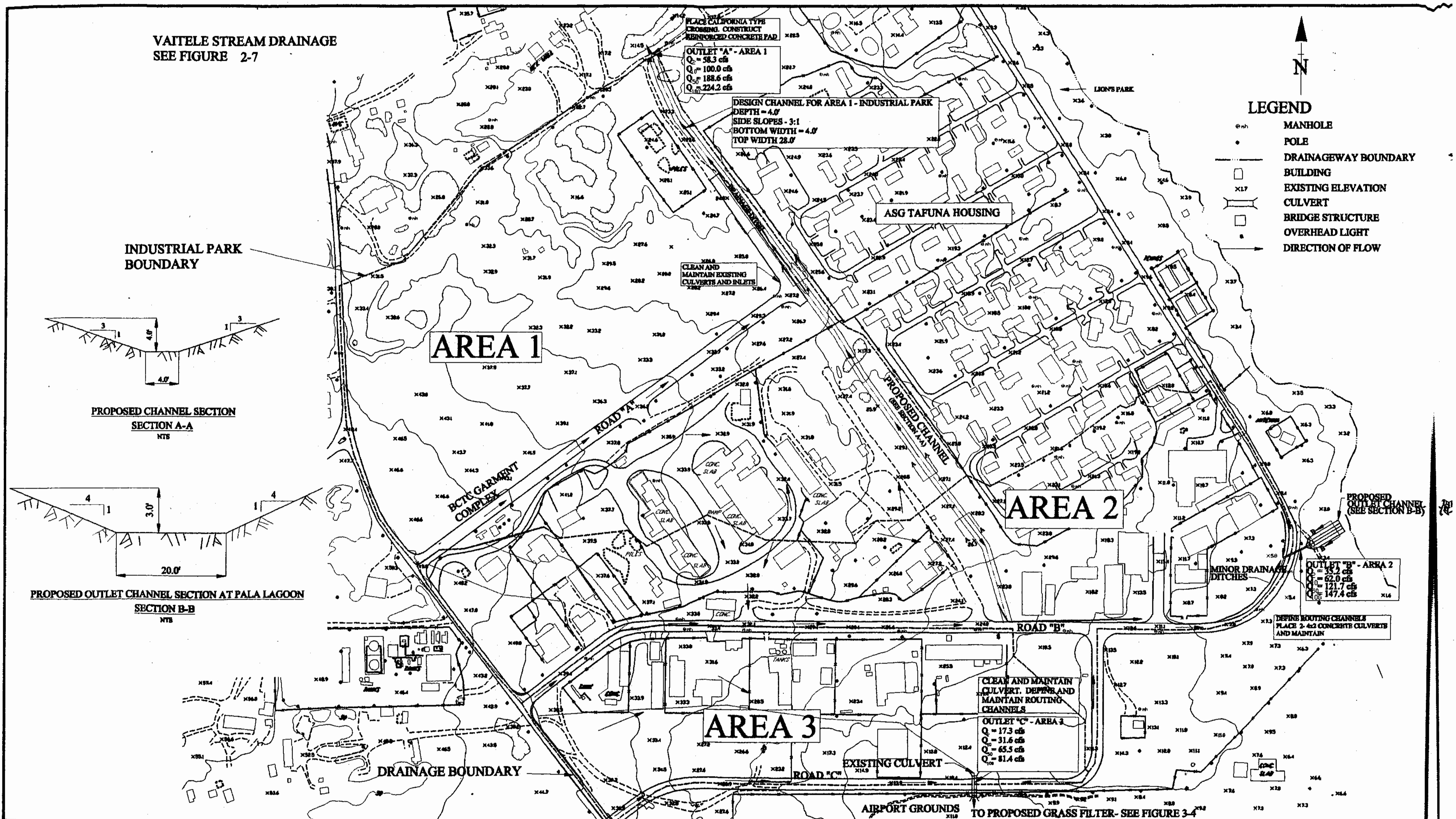
Clear and Maintain Existing Ditch at the East Side of Industrial Park

Existing ditches on the east and south sides of the Industrial Park should initially be cleared of garbage, vegetation and other material that obstruct the drainage of stormwater flows from Drainage Area 1. Following initial clearing of these ditches, periodic maintenance should, in the long-term, be performed by the ASG Department of Public Works on, at least, a quarterly basis.

In view of the proximity of the ASG Tafuna Correctional Facility, consideration should be given to the use of inmates for the performance of such maintenance. ASG personnel and equipment could be used to haul collected solid waste material to the Futiga landfill.

The Public Works maintenance crew and/or inmates will require the following equipment to perform such maintenance:

- weed-eaters and machetes to clear vegetation;
- sledge hammers, picks, shovels, and rakes to remove obstructions and debris from the drainage ditch.



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DANIEL INOUYE INDUSTRIAL PARK
PROPOSED STORMWATER MANAGEMENT

Scale: 1" = 300'

Figure 3-3

The nightly patrol of this area by the ASG Department of Public Safety would also help reduce the amount of drinking activity in the vicinity of the ditch and deter the use of the drainage ditch as a dump site.

Construct New Drainage Ditches

New ditches should be constructed in the undeveloped area south of Lion's Park, as well as on the north side of Pago Pago International Airport. These drainage courses are needed to reduce flooding within the Industrial Park during higher stormwater events. During lower stormwater events, the same ditches can effectively help trap some sediments. These sediments can occasionally be removed via periodic maintenance of the ditches.

The bottom of the ditches should be earth-lined to enable the long-term removal of sediments. Basaltic rock or rock-filled gabions should be used to stabilize the side slopes of the drainage ditches where the potential for erosion is likely. Potential areas could include inlets and outlets of conveyance structures. Channel side slopes could be revegetated with hardy low-growing grasses.

Following construction, both ditches will require long-term maintenance to manage vegetation and collect solid waste material. ASG personnel used to clean storm drain inlets and culverts should also be used to maintain both ditches. Such maintenance should be made, at least, quarterly to minimize potential obstructions to stormwater flow. Following more significant storm events, onsite assessments will also be necessary to determine whether any significant obstructions need to be cleared before the required quarterly maintenance schedule.

Establish a Grass Filter South of Area 3

An additional opportunity for the detention of sediments should also be established on the north side of Pago Pago International Airport complex. This opportunity would include the establishment of a grass filter area on approximately 6.8 acres immediately south of the proposed drainage ditch in Area 3 (Figure 3-4).

The grass filter would make use of existing California grass or other vegetative cover. The grass would be maintained by Tafuna International Airport or ASG Department of Public Works personnel on a monthly basis; the height of the vegetative material would not be permitted to grow beyond two feet in height. Sediment trapped by the filter would need to be removed approximately once every three months.

Order-of-Magnitude Cost Estimates

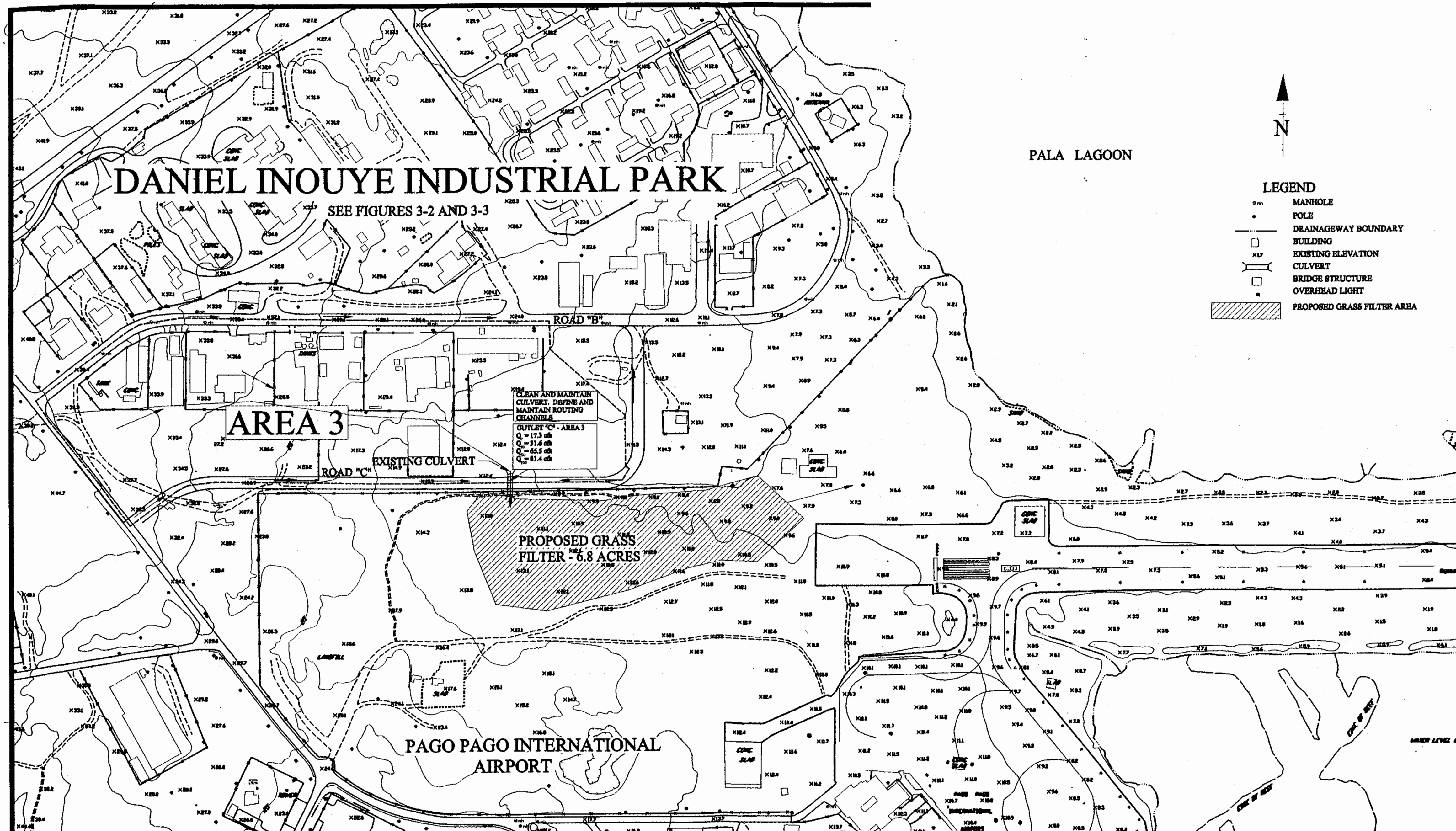
Recommended facility improvements reflect potential costs for:

- the initial clearing of the existing ditch on the east side of the Industrial Park;
- the maintenance of storm drain inlets, stormwater culverts, and drainage ditches; and,
- the construction and extension of new drainage ditches.

Because of the potential variability of existing soils within the Industrial Park, proctor tests, sieve analysis, as well as depth to bedrock investigations should be completed prior to final design and construction of new stormwater facilities. Such conditions may vary significantly to warrant alternate construction techniques and procedures. If so, preliminary construction costs may increase beyond the 15 percent contingency reflected in the order-of-magnitude cost estimates.

Initial Clearing of Existing Ditches

It is recommended that the initial clearing of drainage ditches on the east and south sides of the Industrial Park be accomplished by a private contractor. However, if labor and equipment resources are available, clearly these activities could capably be made by the ASG Department of Public Works.



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DANIEL INOUYE INDUSTRIAL PARK
PROPOSED GRASS FILTER

Scale: 1" = 300'

Figure 3-4

The initial clearing would require the cleaning of approximately 550 linear feet of ditch on the east side of the Industrial Park. Clearing of the ditch and culvert located below Road C would require cleaning of about 100 linear feet of an unlined drainageway (Table 3-4).

TABLE 3-4
ORDER-OF-MAGNITUDE COSTS
INITIAL CLEARING OF DITCHES ON THE EAST AND SOUTH SIDES
DANIEL INOUYE INDUSTRIAL PARK

Location	Quantity (linear feet)	Unit Price	Extension
East side of Industrial Park	550	$15/LF	$8,250
South side of Industrial Park	100	$15/LF	$1,500
		TOTAL	**$9,750**

Source: Pedersen Planning Consultants, 1999

Maintenance of Storm Drain Inlets, Stormwater Culverts, and Drainage Ditches

PPC believes that an existing truck from the ASG Department of Public Works could be used for the hauling of solid waste materials to the Futiga landfill. However, equipment expenditures would need to be made for additional small tools such as weed-eaters, machetes, shovels, picks, and sledge hammers (Table 3-5).

The labor costs represent the anticipated cost for one typical year of maintenance that would be accomplished on four different occasions. It is expected that a full replacement of all tools would need to be made, at least, once every three years.

TABLE 3-5
ORDER-OF-MAGNITUDE COSTS
ANNUAL MAINTENANCE OF STORM DRAIN INLETS,
STORMWATER CULVERTS, AND DRAINAGE DITCHES
DANIEL INOUYE INDUSTRIAL PARK

LABOR				
Personnel	*Number*	*Hours*	*Hourly Rate ($)*	*Cost ($)*
Supervisor	1	64	15	960
Laborer	2	64	6	768
All Personnel	***3***	***192***		***$1,728***
MATERIALS				
Item	*Quantity*		*Unit Cost ($)*	*Cost ($)*
Picks	3		15	45
Sledge Hammers	3		25	75
Shovel	3		22	66
Weed-eaters	3		300	900
Machetes	3		20	60
Garbage Bags	32 boxes		5	160
Wheel Barrows	3		50	150
All Materials				***$1,456***
TOTAL LABOR AND MATERIALS				**$3,184**

Source: Pedersen Planning Consultants, 1999

Construction of New Drainage Ditches

The construction of new drainage ditches will primarily require the use of heavy equipment, e.g., front-end loaders, that can be used to grade drainage courses and establish defined drainage channels. Where necessary, basaltic rock or rock-filled gabions will be needed to stabilize the side slopes of the drainage ditches (Table 3-6).

The interior slopes, as well as inlet and outlet areas, of new ditches or channels will require an evaluation concerning potential susceptibility to erosion as new ditches or channels are more specifically defined, designed, and constructed. The soils assessment will be an important task to ensure long-term effectiveness of the ditch.

TABLE 3-6
0RDER-OF-MAGNITUDE COSTS
CONSTRUCTION OF NEW DRAINAGE DITCHES
AND RELATED IMPROVEMENTS
DANIEL INOUYE INDUSTRIAL PARK

Improvement	Quantity (Linear feet)	Unit Price ($)	Cost ($)
Area 1			
Drainage channel	1,150	50/LF	57,500
Road Crossing	100	250/LF	25,000
		Subtotal	*$82,500*
Area 2			
Minor ditches to route flows	1,250	10/LF	12,500
New ditch to Pala Lagoon	600	30/LF	18,000
Box culverts	200	460/LF	92,000
		Subtotal	*$ 122,500*
Area 3			
Grade ditches along roadside	1,700	10/LF	17,000
New ditch and grass filter to north side of Airport/Pala Lagoon	1,500	50/LF	75,000
		Subtotal	*$ 92,000*
Total of All Projects for Areas 1,2, & 3			*$ 297,000*
15% Contingency			*44,550*
TOTAL COST			**$ 341,550**

Source: Pedersen Planning Consultants, 1999

Other Stormwater Management Recommendations

Stormwater Management Fund

In order to ensure that recommended stormwater maintenance activities are carried out, it is important that the American Samoa Government seek practical and reasonable methods for establishing a stormwater management fund for the Daniel Inouye Industrial Park. This fund could be developed and sustained through ASG's collection of monthly or annual stormwater management fees from existing and future lessees of properties within the Industrial Park. Such requirements will likely require some revisions to existing lease agreements.

CHAPTER FIVE
VATIA WATERSHED

STUDY AREA LOCATION

The Vatia watershed planning area, which is defined by natural resource managers in American Samoa and the American Samoa Watershed Protection Plan, includes approximately 1.9 square miles of land area (Figure 5-1). There are approximately 10 streams in this watershed planning area.

STUDY OBJECTIVE

This stormwater evaluation focused upon potential opportunities for the detention of stormwater runoff and sedimentation that otherwise discharge into Vatia Bay. The intent of this study was to determine viable stormwater management improvements that will:

- reduce the discharge of sediments into Vatia Bay and improve nearshore water quality;
- reduce flooding in portions of the inhabited village area on the southeast and northwest side of Vatia Village; and,
- increase inland recreational opportunities for Vatia Village residents.

HYDROLOGY

General Drainage Characteristics

Stream Discharges

The ten streams in the Vatia watershed drain moderate and steeper slopes of the watershed that generally lie upslope of the shoreline village area. Nine streams discharge into Vatia Bay (Figure 5-1). Upslope of the shoreline village area, these drainages generally remain undeveloped.

An unnamed stream (stream 10C) is located in the vicinity of Amalau. However, this stream discharges into the unnamed embayment east of Vatia Bay.

Stream Flows

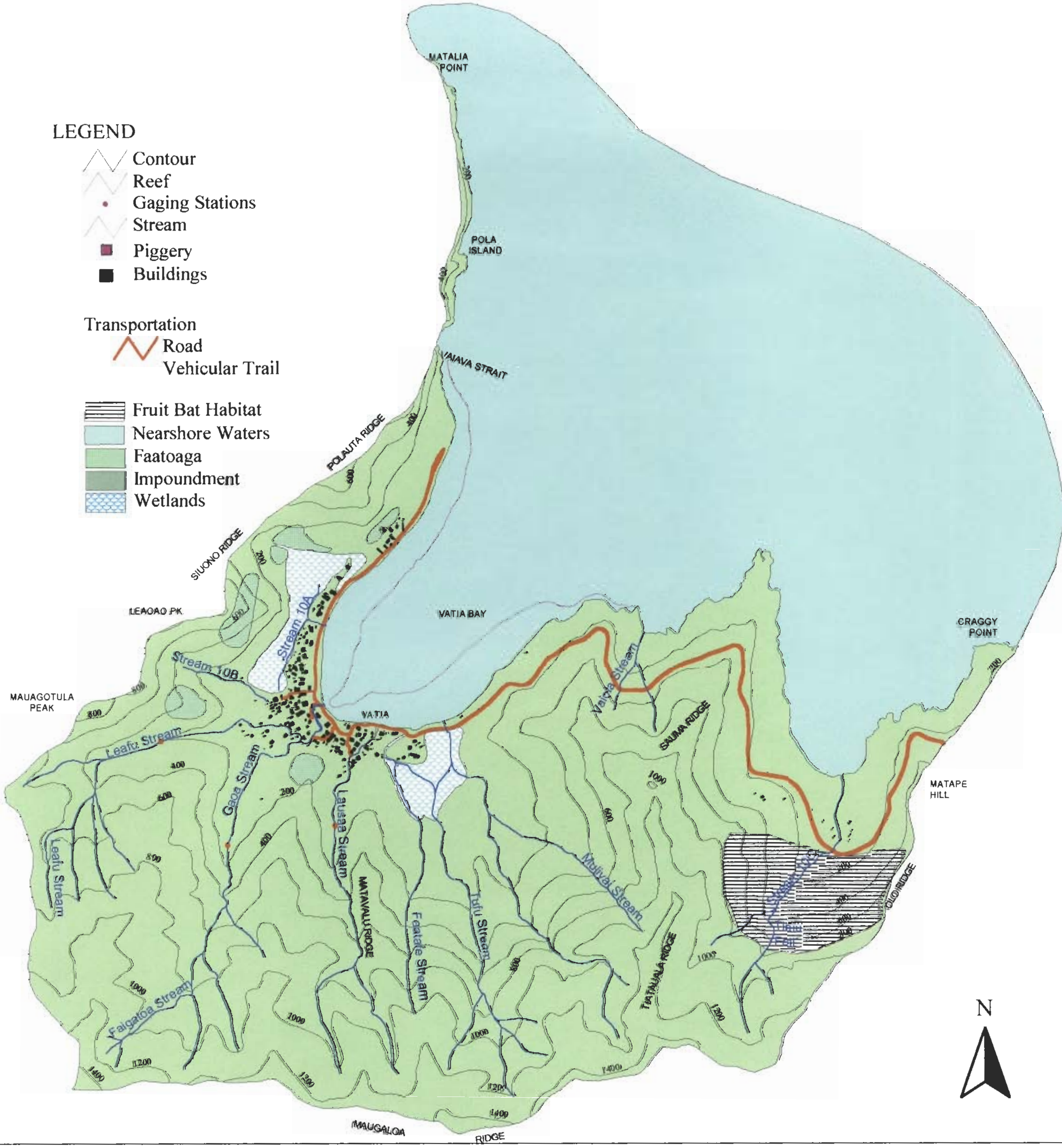
In 1996, the U.S. Geological Survey estimated the median stream flow for three streams in the Vatia watershed planning area (Table 5-1). These estimates were based upon historical, intermittent stream flow measurements made by the U.S. Geological Survey.

Available stream flow records and related estimates by the U.S. Geological Survey suggest that the primary drainage in the Vatia watershed occurs via discharges from Gaoa Stream, Leafu Stream, and Lausaa Stream. These streams all discharge near the head of Vatia Bay.

TABLE 5-1
MEDIAN STREAM FLOW ESTIMATES
STREAMS IN THE VATIA WATERSHED

Stream	USGS Gage Station	Gage Location	Stream Flow Measurements (number)	Estimated Median Flow (cfs)
Leafu Stream	16914000	0.3 mile upstream from stream mouth	11	0.25
Gaoa Stream	16913000	0.4 mile upstream from stream mouth	8	0.26
Lausaa Stream	None	1,000 feet upstream from Faatafe Stream	1	0.20

Source: Wong, 1996



American Samoa Geographical Information System

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Miles

Scale: 1:20,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Vatia Watershed **10**

Existing Conditions

Figure 5-1

Wetlands

The two wetlands in the Vatia watershed detain a limited amount of surface runoff from stream discharges and sheet flows within the watershed. Long-term sediment retention within both wetlands has gradually reduced the capacity of these wetlands to detain stormwater flows. At best, both wetlands probably afford some limited deposition of sediments during smaller stormwater events, e.g., 2-year storm.

Mulivai Stream, Tufu Stream, and Faatafe Stream discharge into a fresh-water wetland located on the southeast side of Vatia Village. The wetland contains approximately 15 acres of land area that are situated between 4 and 20 feet above mean sea level. A Mormon Church complex and several homes have likely been constructed within the original wetland. Two separate outlets from the wetland are located underneath the shoreline road that fronts Vatia Village.

A seven-acre coastal marsh is located on the northwest side of Vatia Village between the 10 and 20-foot contour. This wetland detains some surface runoff from Siuono Ridge and Polauta Ridge, as well as an unnamed stream (stream 10A). This wetland was once used for taro cultivation (Whistler, 1976). Field observations in May, 1998 indicate that the wetland is now used for the production of some subsistence crops such as banana.

Stormwater Runoff

U.S. Army Corps of Engineer Estimates

A flood insurance study was published by the Federal Emergency Management Agency (FEMA) in May, 1991. This study included flood risk data for selected areas on the Island of Tutuila that were intended to:

- facilitate the establishment of actuarial flood insurance rates; as well as,
- provide information that could be used for local floodplain management efforts in American Samoa.

The U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses in 1987 that supported the FEMA study. This study included analyses of four streams in the Vatia watershed. One hundred-year peak discharges were calculated for each of these streams (Table 5-2).

TABLE 5-2
ESTIMATED 100-YEAR PEAK DISCHARGES
SELECTED STREAMS IN THE VATIA WATERSHED

Stream	Location	Drainage Area (square miles)	100-Year Peak Discharge (cfs)
Gaoa	stream mouth	0.45	1,330
	above confluence with Leafu Stream	0.25	790
Faatafe	above confluence with Lausaa Stream	0.07	240
	stream mouth	0.20	640
Tufu	stream mouth	N/A	195
	above confluence with Tafu Stream right tributary	0.11	390
Tufu right tributary	between Tufu and Mulivai Stream	N/A	195
Mulivai	stream mouth	N/A	890
	above confluence with Tufu Stream right tributary	0.22	690

Note: PPC believes that Faatafe Stream has no confluence with Lausaa Stream as presented by FEMA in Table 5-2.
Source: Federal Emergency Management Agency, 1991

Available data suggests that a potential 100-year storm event will generate significant discharges of stormwater runoff at the mouths of Gaoa, Faatafe, and Mulivai Streams. No estimates of potential discharges from streams 10A or 10B were made by the U.S. Army Corps of Engineers.

Computer Modeling of Potential Stormwater Detention Areas

Existing wetlands in the Vatia watershed provide an opportunity to detain some stormwater runoff from local streams. In light of this opportunity, Pedersen Planning Consultants modeled potential discharges of surface runoff into these wetlands for 2, 10, 50, and 100-year storm events (Tables 5-3 and 5-4).

The computer modeling of potential stormwater events into these wetland areas suggests that potential stormwater flows to the wetland on the southeast side of Vatia Bay range between 504 cubic feet per second (cfs) for a 2-year storm event and 1,559 cfs for a 100-year storm (Table 5-3).

TABLE 5-3
STORMWATER RUNOFF DISCHARGES INTO WETLAND
SOUTHEAST SIDE OF VATIA BAY
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Faatafe Stream mouth	23	42	84	104
Tufu/Mulivai Stream mouths	481	731	1,133	1,455
All Streams	**504**	**773**	**1,217**	**1,559**

Source: Pedersen Planning Consultants, 1998

The coastal marsh on the northwest side of Vatia Village presently receives considerably less runoff from similar stormwater events. It is estimated that a 2-year storm generates approximately 163 cubic feet per second of surface runoff into the marsh; roughly 831 cfs of surface runoff discharges into the wetland during a 100-year storm event (Table 5-4).

TABLE 5-4
STORMWATER RUNOFF DISCHARGES INTO COASTAL MARSH
NORTHWEST SIDE OF VATIA VILLAGE
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Stream 10A	150	292	547	743
Surface runoff from upland slopes	13	34	64	88
All Surface Runoff	**163**	**326**	**611**	**831**

Source: Pedersen Planning Consultants, 1998

In the modeling of surface runoff, it was assumed that the both wetlands would be able to hold an average depth of approximately six feet of runoff. To achieve such depth, some sediments would be excavated from both wetlands. In addition, an impermeable structure would need to be constructed around the perimeter of both wetlands.

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding

Northwest Side of Vatia Village

Since the occurrence of Hurricane Val in December, 1991, some localized flooding has occurred on the northwest side of Vatia Village. The flooding has impacted the lands in the vicinity of the last two homes on the northwest side of the village. These homes are located on southwest of the new elementary school and east of the coastal marsh.

The flooding that occurs on the seaward side of these homes and in an adjoining *faatoaga* stems from, at least, three factors:

- the coastal marsh has limited capacity to detain stormwater as sediments have, in the long term, decomposed and gradually filled much of the marsh with a highly saturated soil;
- stormwater flows frequently overflow from the northwest side of the wetland to adjoining residential housing and subsistence agricultural area;
- a culvert underneath the shoreline trail that fronts this part of the village was buried by coral and sand transported inland by Hurricane Val.

South and West Sides of Vatia Village

Flood insurance rate maps, which were developed by FEMA in 1991, suggest that there is inland flood potential for:

- the lower reaches of Gaoa Stream and Leafu Stream;
- the lower drainages associated with Faatafe Stream and Tufu Stream; and,
- lower Mulivai Stream drainage.

The primary concern is along portions of the lower Gaoa Stream drainage where increased resident development is expected to occur during the next 20 years. In the lower Gaoa Stream drainage, residential development is anticipated up to the 50-foot contour. Available flood insurance rate map for the Vatia area suggests that a potential 100-year flood would extend roughly 1,100 feet inland from the Gaoa Stream mouth. Consequently, a potential 100-year flood could impact future residential development in this area.

Most of the potential 100-year flood area associated with Faatafe, Tufu, and Mulivai Streams are located within the wetland on the east side of Vatia Bay. However, the Mormon Church complex and several homes between the mouths of Faatafe and Mulivai Stream are located in this area and could sustain damage from a 100-year flood.

Sedimentation

The sedimentation of local streams occurs is typically generated during and following heavier rainfall events. Sediments usually accompany stormwater runoff that is discharged from local streams and steeper upland slopes.

The source of sediments being discharged into local streams is derived from more erosive soils along the upper slopes of the Vatia watershed. These include soils from the Fagasa family-Lithic Hapludolls-Rock Outcrop Association, as well as Aua very stony silty clay loam. Surface runoff carries eroded soil material into the nine streams that discharge into Vatia Bay.

The presence of feral pigs on upland slopes of the Vatia watershed compounds the erosion of more erosive soils in the upland Vatia watershed. A two-week survey of various parts of the National Park of American Samoa in November, 1995 provided evidence that feral pigs root, wallow, and graze upon vegetation along steeper slopes of the drainage and plateau areas immediately below upland mountain ridges. During his November, 1995 survey, Hoshide observed considerable erosion of the surface soil layer along stream banks where vegetative ground cover had been dug up and soil loosened by feral pigs (Cook, 1998).

The discharge of sediments into Leafu Stream and Lausaa Stream is an important stormwater management consideration since surface water supplies are located along both streams. Increased sediments along these waterbodies will only decrease the water quality of these water supplies, which already show signs of bacterial contamination.

The discharge of sediments into these and other streams in the Vatia watershed, which ultimately discharge into the nearshore waters of Vatia Bay, is also of concern. Significant turbidity and sedimentation do not promote long-term nutrition, growth, reproduction, and depth distribution of nearshore coral communities (Richmond, 1993)

Direct discharges of sediments accompany the discharge of surface runoff from streams 10B, Gaoa Stream, and Lausaa Stream. However, no modeling was made of these streams to calculate levels of existing sediment loading. While sedimentation from these streams is probably significant, field observations in the watershed that stormwater detention opportunities along these drainages do not appear feasible in light of topographic and land use characteristics.

PPC's modeling of various storm events suggest that sediment discharges from Faatafe, Tufu, and Mulivai streams range from approximately 109 tons of sediment from a 2-year storm to roughly 361 tons that is generated from a 100-year storm event. On the west side of Vatia Bay, the 136-acre drainage area that drains into the coastal marsh generates a discharge of about 30 tons of sediment from a 2-year storm event and 163 tons from a 100-year storm. While existing wetlands provide an opportunity for the deposition of sediments, long-term sediment accumulation has gradually reduced the capacity of these wetlands to detain stormwater runoff and permit sediment deposition. This is particularly true during heavier stormwater events, e.g., 10-year storm or greater.

The detention of surface runoff is needed to help reduce the amount of sediment that is discharged into Vatia Bay via stormwater events. Existing wetlands on the southeast and west sides of Vatia Bay represent the best opportunities for stormwater detention. Most of the lower portions of the watershed are already urbanized by residential and commercial land uses.

Marine Resources and Related Water Quality

Vatia Bay is characterized by a fringing coral reef that fronts the entire embayment. The width of the reef extends varies, but generally extends between 400 to 500 seaward of the shoreline.

The reef front of the fringing coral reef has been surveyed by various private consultants since the late 1970's. Green most recently observed that the fringing reef in Vatia Bay has recovered significantly from the damage incurred from Hurricane Val. in 1991. Coral coverage observed in 1996 was 40 percent or greater at a depth of about 10 meters. This coverage was three times greater than the coverage documented in 1994 (Green, 1996).

The reef provides significant habitat to fishes and other marine organisms. In turn, a number of residents occasionally use the nearshore waters for subsistence and recreational fishing.

A reduction of turbid stormwater runoff and sediment discharges will help maintain the health of the fringing coral reef communities and promote future growth. Corals are dependent upon the availability of light and related photosynthesis.

Water Quality Standards

The water quality standards for American Samoa, which were most recently revised in 1989, identify the waters of Vatia Bay as an embayment. Surface water quality standards that are applicable to Vatia Bay and other embayments in American Samoa are summarized in Table 5-5.

TABLE 5-5
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO VATIA BAY AND OTHER EMBAYMENTS

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	0.35	NTU
Total Phosphorus	20.00	microngrams per liter
Total Nitrogen	150.00	microngrams per liter
Chlorophyll a	0.50	microngrams per liter
Dissolved Oxygen	Not less than 75% saturation or less than 5.0 mgl. If the natural level of DO is less than 5.0 mgl, the natural level shall be the standard.	milligrams per liter
Light Penetration Depth	Exceed 120 feet 50% of the time.	feet
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

In the outer lagoon, water quality samples were collected at depths of 3 and 60 feet in July and August, 1992. Nutrient levels that were measured from these samplings were well within ASEPA water quality standards. However, the chlorophyll a standard of 0.50 microngrams was exceeded at the 60-foot depth. Otherwise, laboratory results gained from these intermittent water quality samples are too limited to make any determinations concerning the water quality of Vatia Bay.

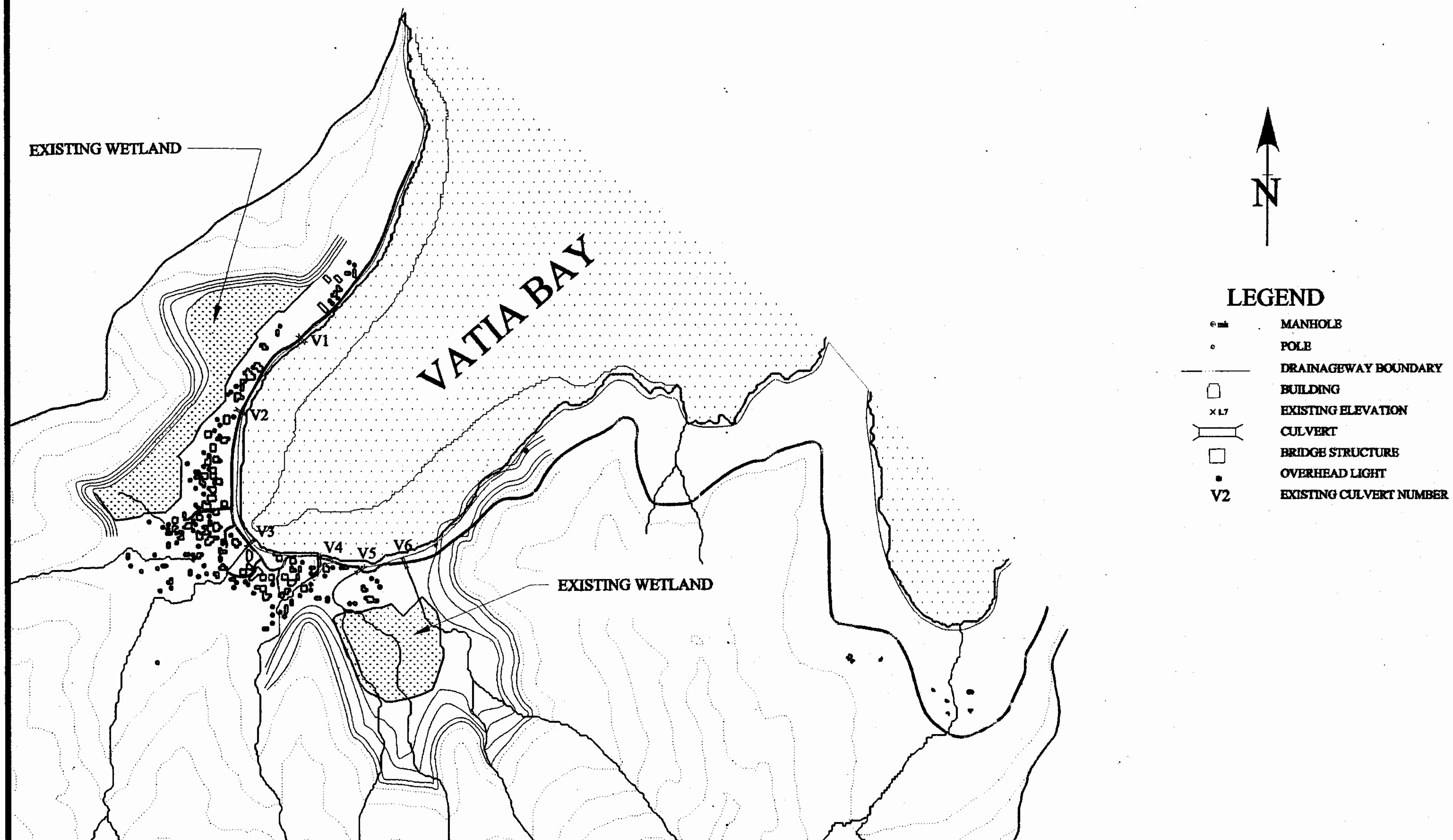
STORMWATER MANAGEMENT FACILITIES

In Vatia, there are six culverts (V1 through V6) between the northwest end of the inhabited village area and Mulivai Stream on the south side of Vatia Bay (Figure 5-2). These culverts enable the discharge of stormwater runoff from local streams, upland slopes, and wetland outlets to the nearshore waters of Vatia Bay. These culverts include a variety of box and circular culverts that were constructed through the use of concrete, corrugated metal and plastic pipe, and old barrels.

Prior to the occurrence of Hurricane Val in December, 1991, a seventh culvert existed just north of Culvert V1. Local storm waves generated from this storm transported coral rubble inshore to the northwest shoreline of Vatia Bay. As a result, the seventh culvert was buried by incoming coral rubble and sand.

Condition and Deficiencies

A field survey of the six culverts in May, 1998 revealed that existing culverts are generally in good structural condition. One exception is culvert V1 on the northwest side of Vatia Bay, which was constructed through the use of old barrels. In May, 1998, only concrete and metal rings remain. The physical characteristics and deficiencies associated with each culvert are summarized in Table 5-6.



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VATIA WATERSHED
EXISTING STORMWATER MANAGEMENT

Scale: NOT TO SCALE

Figure 5-2

TABLE 5-6
STORMWATER CULVERTS
CONDITIONS, DEFICIENCIES, AND RECOMMENDED IMPROVEMENTS
MAY, 1998

Culvert	Size (feet)	Type	Material	Condi-tion	Required Flow for 50-Year Event (cfs)	Deficiency	Needed Improvements	Estimated Cost ($)
V1	2 (diameter)	Circular	Concrete and metal rings (old barrels)	Poor	71	Blocked 90% on west side; 40% on east side.	None, if detention pond is constructed	0
V2	2.6 (diameter)	Circular	Corrugated plastic	Fair	449	Considerable trash accumulation	None, if detention pond is constructed	0
V3	20 x 6.6	Box	Concrete	Good	549	None	None	0
V4	18.3 x 4.0	Box	Concrete	Good	422	None	None	0
V5	17.5 x 5.0	Box	Concrete	Good	85	None	None	0
V6	3-3.0 (diameter)	Circular	Concrete	Fair	832	Undersized	None, if detention pond is constructed	0

Source: Pedersen Planning Consultants, 1998

However, these culverts frequently become clogged with debris, vegetation, and garbage during and following stormwater events. In May, 1998, significant accumulations of garbage were observed within or along inlet and outlet sides of culverts V2 and V6. Sediments and vegetation blocked 90 percent of the inlet and 40 percent of the outlet side of Culvert V1. Regular periodic maintenance is required to make effective use of the culverts and reduce flood potential.

Recommended Facility Improvements

Proposed improvements to stormwater culverts V1 through V6 are summarized in Table 5-6. Recommended improvements primarily include the removal of obstructions, debris, and vegetation that block stormwater flows through some of the culverts along Vatia Bay. The initial cleaning of these culverts needs to be followed with scheduled maintenance of all culverts on a quarterly basis.

Only one of the culverts, V6, is undersized to accommodate a 50-year event. With the installation of a larger culvert at V6, all Culverts V1 through V6 will be capable of accommodating flows from a 50-year event.

Recommended Maintenance of Stormwater Culverts

Regular periodic maintenance of stormwater Culverts V1 through V6 is required to reduce potential localized flooding and emergency responses by public works personnel.

It is recommended that a three-person crew be organized by the ASG Department of Public Works to maintain these culverts, at least, four times per year. This crew should remove vegetation, garbage, and other debris that reduce the flow of stormwater discharges through culverts. Such maintenance should extend along each of the six stream courses or wetlands approximately 50 feet upstream and 50 feet downstream of culvert inlets and outlets, as well as inside the culverts.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes that can be used to clear vegetation;
- sledge hammers, picks, shovels, and rakes that can be used to remove obstructions and debris from stream course areas immediately adjacent to culvert inlets and outlets;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose that can be used to clear debris inside closed culverts; and,
- small truck to haul collected solid waste material and garbage from each stream course and culvert.

STORMWATER DETENTION OPPORTUNITIES

Two wetlands in the Vatia watershed represent potential stormwater detention opportunities:

- a coastal marsh on the northwest side of Vatia Village; and,
- a cultivated fresh-water wetland on the southeast side of Vatia Village that is situated inland of the Faatafe and Mulivai Stream mouths.

Both of these wetlands represent attractive stormwater detention opportunities since both wetlands already provide some limited stormwater detention. Any alteration of these wetlands would be made to increase their capability to detain stormwater runoff and capture sediments.

Coastal Marsh on the Northwest Side of Vatia Village

Site Location

The coastal marsh on the northwest side of Vatia Village, which contains approximately seven acres of saturated soils and scattered vegetation, lies immediately upslope of low-density residential area (Figure 5-3). In May, 1998, no significant use of the coastal marsh was observed. Some evidence of some past agricultural use was documented on steeper slopes immediately northwest of the wetland.

General Design Concept

The continued use of all or a portion of the coastal marsh for stormwater detention could help reduce the amount of turbid runoff and sedimentation into Vatia Bay. To achieve a greater reduction, the proposed detention area would be excavated to about the 10-foot elevation. In essence, roughly five to six feet of soil would initially be removed from the coastal marsh to afford a greater amount of potential detention.

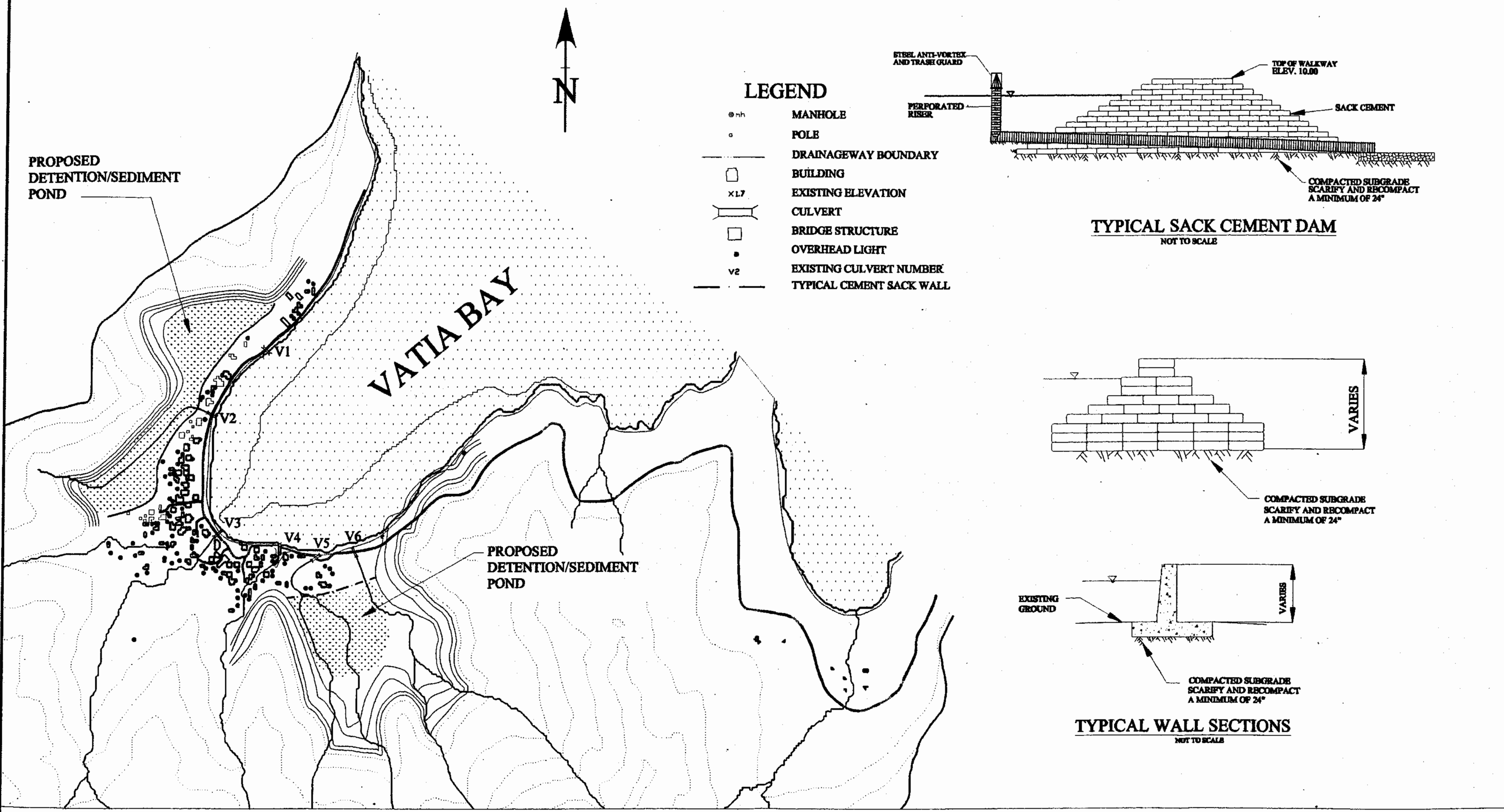
A five to six-foot high wall would be constructed along the east boundary of the coastal marsh. The wall would be constructed through the use of small bags of cement that would be hand-carried and placed along the pond perimeter. The maximum side slope of the wall would contain a 4:1 slope.

The wall would be back-filled with native soil to reduce the visual impact of the concrete bags. Selected landscape materials would be planted along the outside of the pond perimeter to further enhance the attractiveness of the detention area. Landscaping around the perimeter of the detention pond would be accomplished by ASEPA and ASCC Land Grant Program.

In order to increase project benefits to Vatia residents, about two acres on the northwest end of the coastal marsh could be filled, grassed, and made available for general outdoor recreational activities. The area could be maintained by the village *aumaga*.

Project Development Costs

Construction of the detention pond would cost roughly $233,450 (Table 5-7).



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VATIA WATERSHED
PROPOSED DETENTION PONDS

Scale: NOT TO SCALE

Figure 5-3

TABLE 5-7
ORDER-OF-MAGNITUDE COST ESTIMATE
DEVELOPMENT OF DETENTION POND IN COASTAL MARSH
NORTHWEST SIDE OF VATIA VILLAGE

Item	Unit Cost	Quantity	Extension
Mobilization	Lump Sum	1	$ 5,000
Clear and Grubbing	Lump Sum	1	5,000
Excavation	$10/Cubic Yard	10,000	100,000
Berm Construction	$100/Linear Foot	650	65,000
Outlets	$5,000/Each	2	10,000
Culverts, 49x33 ARCH	$150/Linear Foot	120	18,000
		Subtotal	*$203,000*
		15% Contingency	*30,450*
		TOTAL	**$233,450**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

If constructed, a detention pond facility in the coastal marsh on the west side of Vatia Village could provide some nominal reduction in the amount of sediment that otherwise would be discharged into Vatia Bay (Table 5-8). It is estimated that roughly 30 tons of sediment could be detained from a 2-year storm event. Some 163 tons of sediment would be detained from a 100-year storm event.

TABLE 5-8
ESTIMATED SEDIMENT DETENTION
ACHIEVED VIA CONSTRUCTION OF DETENTION POND
WITHIN COASTAL MARSH
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
30	61	123	163

Source: Pedersen Planning Consultants, 1999

Stormwater overflows from the improved wetland will be re-directed to the Stream 10A rather than the northeast side of the wetland. Consequently, some increased flood protection will be provided to the northwest end of the village where occasional flooding now occurs.

Cultivated Fresh-Water Wetland on the Southeast Side of Vatia Village

Site Location

The cultivated fresh-water wetland on the southeast side of Vatia Village encompasses about 15 acres. The wetland was probably encroached upon by past development of the Mormon Church complex and adjacent residential development.

General Design Concept

Improvements to the cultivated fresh-water wetland could enable a reduction in the amount of turbid runoff and sedimentation that discharges into Vatia Bay. To achieve a greater reduction, the wetland would be excavated to about the 2-foot elevation. In essence, an average of roughly five to six feet of soil would initially be removed from the bottom of the wetland to afford a greater volume of stormwater detention and sediment deposition.

A five to six-foot high wall would be constructed along the north boundary of the cultivated fresh-water wetland. The wall would be constructed through the use of small bags of cement that would be hand-carried and placed along the perimeter of the wetland. The maximum side slope of the wall would contain a 4:1 slope.

The wall would be back-filled with native soil to reduce the visual impact of the concrete bags. Selected landscape materials would be planted along the outside of the wetland perimeter to further enhance the attractiveness of the detention area. Landscaping around the perimeter of the detention pond could be accomplished by ASEPA and ASCC Land Grant Program.

Project Development Costs

Construction of the detention pond would cost roughly $425,000 (Table 5-9). The use of village labor would likely help reduce the cost of the detention pond.

TABLE 5-9
ORDER-OF-MAGNITUDE COST ESTIMATE
DEVELOPMENT OF DETENTION POND
IN CULTIVATED FRESH-WATER WETLAND
SOUTHEAST SIDE OF VATIA VILLAGE

Item	Unit Cost	Quantity	Extension
Mobilization	Lump Sum	1	$ 5,000
Clear and Grubbing	Lump Sum	1	5,000
Excavation	$10/Cubic Yard	15,000	150,000
Berm Construction	$100/Linear Foot	2,000	200,000
Outlets	$5,000/Each	2	10,000
		Subtotal	*$370,000*
		15% Contingency	*55,500*
		TOTAL	**$425,500**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

If constructed, the cultivated fresh-water wetland on the southeast side of Vatia Village could provide some nominal reduction in the amount of sediment that otherwise would be discharged into Vatia Bay (Table 5-10). Roughly 109 tons of sediment could be detained from a 2-year storm event. Some 361 tons of sediment would be detained from a 100-year storm event.

TABLE 5-10
ESTIMATED SEDIMENT DETENTION
ACHIEVED VIA CONSTRUCTION OF DETENTION POND
WITHIN CULTIVATED FRESH-WATER MARSH
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
109	172	279	361

Source: Pedersen Planning Consultants, 1999

With the establishment of a cement dam increased capability to store a greater volume of stormwater flows, greater flood protection will likely be afforded to both the Mormon Church complex and adjacent residential area.

CHAPTER FOUR
PAGO PAGO WATERSHED

STUDY AREA LOCATION

The Pago Pago watershed planning area, which is defined by natural resource managers in American Samoa and the American Samoa Watershed Protection Plan, includes approximately 4.0 square miles of land area (Figure 4-1). There are approximately 27 streams and related drainage areas in this watershed planning area.

STUDY OBJECTIVE

This stormwater evaluation focused upon the stormwater runoff and sedimentation that discharges into Pago Pago Harbor from Vaipito Stream. The feasibility and value of potential stormwater detention opportunities were examined to determine viable stormwater management improvements that will:

- reduce the discharge of sediments into Pago Pago Harbor;
- reduce flooding on the east side of Pago Plaza;
- contain stormwater flows within Pago Park; and, at the same time,
- maintain recreational opportunities in Pago Park.

HYDROLOGY

General Drainage Characteristics

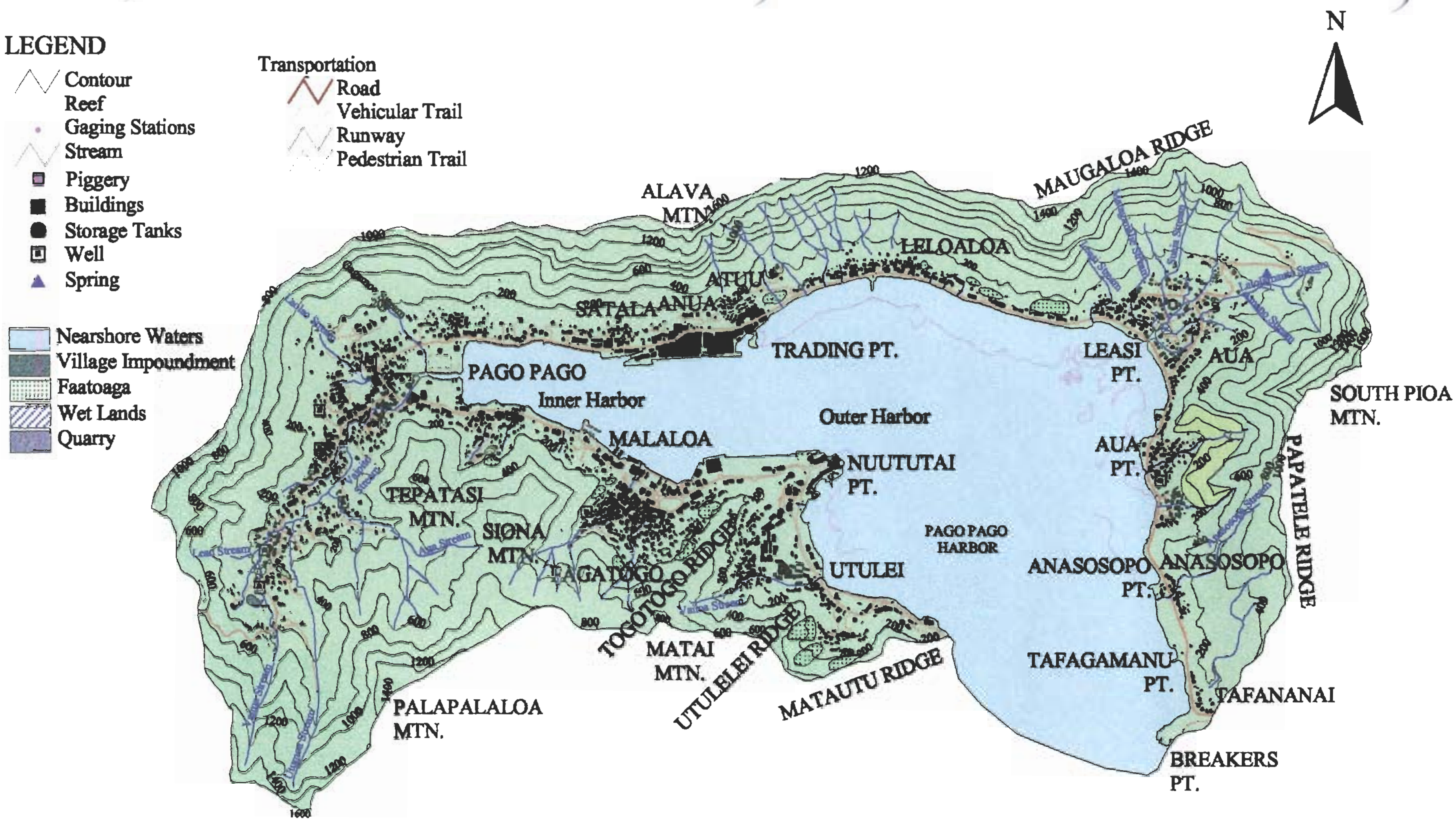
The 27 streams in the Pago Pago watershed drain moderate and steeper slopes of Mt. Alava, Palapalaloa Mountain, and several mountain ridges upslope of Pago Pago Harbor. Eleven of these streams, which are located between Satala and Malaloa, discharge directly into the inner portion of Pago Pago Harbor. Vaipito Stream is the prominent drainage that discharges into the inner Harbor.

Vaipito Stream Drainage

The Vaipito Stream drainage encompasses approximately 1.36 square miles of land area (U.S. Army, Corps of Engineers, Honolulu District, 1990). This drainage receives surface flows from Gagamoe Stream, Laolao Stream, Pago Stream, Leau Stream, Vaima Stream, Utumoa Stream, and Aga Stream (Figure 4-2).

The Vaipito Stream drainage originates near the 1,200-foot contour on the northwest side of Mt. Matafao. The main branch of Vaipito Stream passes through Pago Pago Village. Before discharging into the inner Harbor, the stream passes northwest of Pago Plaza and a channel that bisects Pago Park.

The drainage channel that bisects Pago Park also receives discharges from a second unnamed ditch and channel that is located on the south and east sides of Pago Pago Elementary School. This channel passes on the north side of a Mormon church complex (adjacent to the primary shoreline roadway) and continues approximately 800 feet before its confluence with the main branch of Vaipito Stream.



American Samoa Geographical Information System

Miles
Scale: 1:32,000

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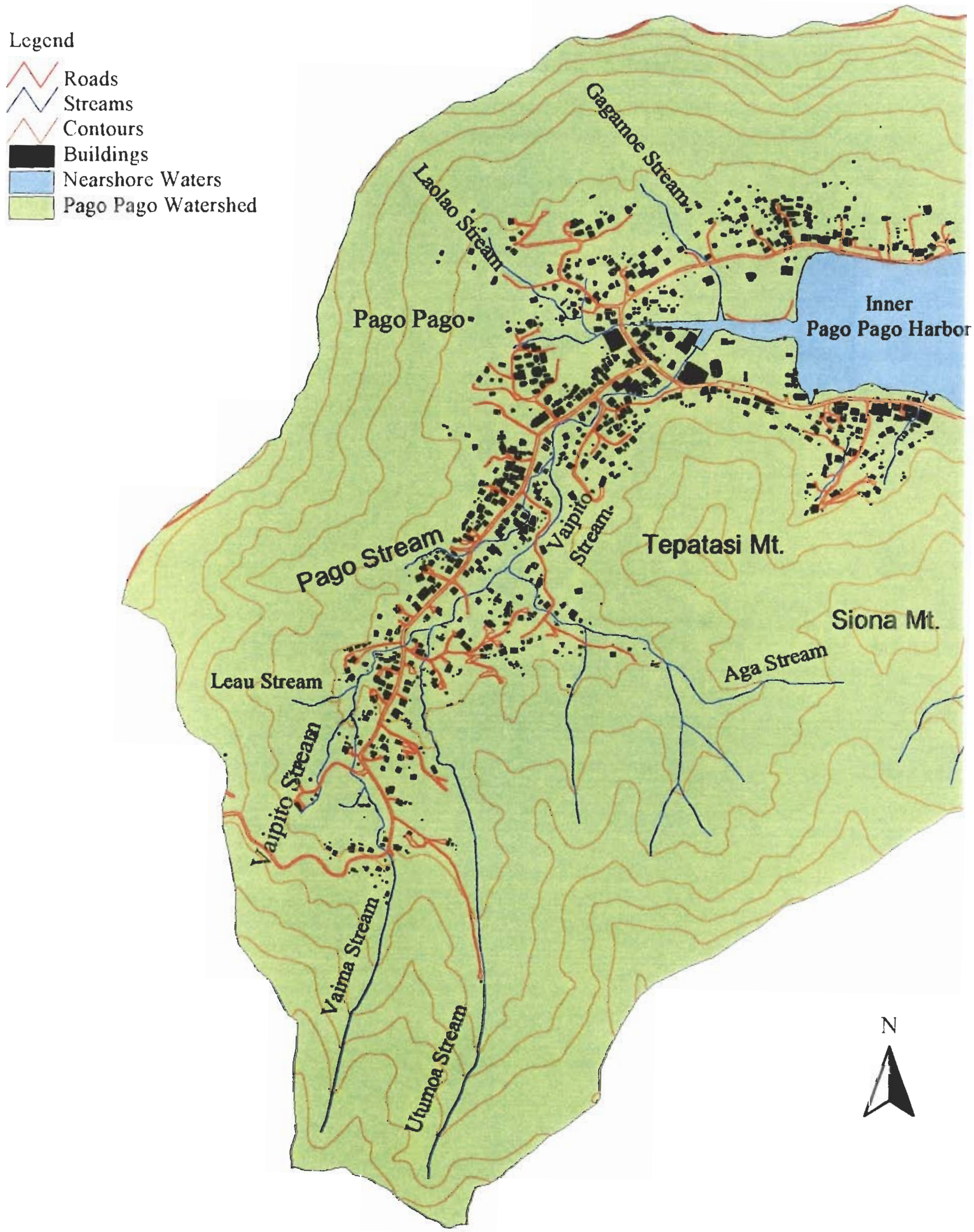
Pago Pago Watershed Existing Conditions

24

Figure 4-1



American Samoa Geographical Information System

Not to Scale

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Vaipito Stream Drainage Location Map

Figure 4-2

Stream Flows

In 1996, the U.S. Geological Survey estimated the median stream flow for two streams in the Vaipito Stream drainage (Table 4-1). These estimates were based upon historical, intermittent stream flow measurements made by the U.S. Geological Survey.

TABLE 4-1
MEDIAN STREAM FLOW ESTIMATES
STREAMS IN THE VAIPITO STREAM DRAINAGE

Stream	USGS Gage Station	Gage Location	Stream Flow Measurements (number)	Estimated Median Flow (cfs)
Vaima Stream	16949700	0.4 mile upstream of Vaipito Stream	20	0.16
Utumoa Stream	16949800	0.6 mile upstream of Vaipito Stream and immediately upstream of Vaipito intake	29	0.42
Utumoa Stream	16950500	0.2 mile downstream of Utumoa Stream pipeline	17	0.25

Source: Wong, 1996

Stormwater Runoff

Stormwater discharges into inner Pago Pago Harbor are primarily generated from heavier rainfall events that occur within the Vaipito Steam drainage area.

Computer modeling of the Vaipito Stream drainage by Pedersen Planning Consultants suggests potential stormwater discharge at the stream mouth that ranges between 862 cubic feet per second (cfs) for a 2-year storm event and 3,683 cfs for a 100-year storm event (Table 4-2).

TABLE 4-2
STORMWATER RUNOFF DISCHARGES INTO INNER PAGO PAGO HARBOR
FROM VAIPITO STREAM DRAINAGE
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Vaipito Stream	612	1,084	2,137	2,608
Unnamed Stream	220	391	775	947
Gagamoe Stream	30	53	104	128
TOTALS	**862**	**1,528**	**3,016**	**3,683**

Source: Pedersen Planning Consultants, 1999

Correlation With Other Stormwater Runoff Estimates

The U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses in a 1990 feasibility report for potential flood damage reduction along Vaipito Stream. The 100-year peak discharges calculated for Vaipito Stream were significantly higher than those determined by Pedersen Planning Consultants in 1998 (Table 4-3). The difference between these estimates is believed to result from the use of different stormwater modeling methods (See Chapter One).

TABLE 4-3
U.S. ARMY CORPS OF ENGINEER ESTIMATES
100-YEAR STORMWATER FLOW

Location Along Vaipito Stream	Drainage Area (square miles)	2-Year Storm (cfs)	10-Year Storm (cfs)	50-Year Storm (cfs)	100-Year Storm (cfs)	500-Year Storm (cfs)
Stream mouth	1.36	1,980	3,000	3,950	4,360	5,730
Between Laolao Stream & Gagamoe Stream	1.26	1,780	2,700	3,600	4,000	5,270
Just above confluence with Laolao Stream	0.96	1,230	1,990	2,710	3,050	3,950
Above the primary shoreline roadway	0.94	1,190	1,900	2,600	2,920	3,790
Just above confluence with Pago Stream	0.78	930	1,530	2,150	2,420	3,200
Just below confluence with Fitiuli Stream	0.76	890	1,460	2,020	2,300	3,030
Just above confluence with Fitiuli Stream	0.48	480	860	1,280	1,480	2,030

Source: U.S. Army Corps of Engineers, Honolulu District, 1990

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding Along the Lower Reaches of Vaipito Stream

During at least the past 20 years, localized flooding has occurred along portions of the primary shoreline roadway in Pago Pago Village, as well as portions of the inhabited village area. Past damages have been more prevalent in the downstream reaches of Vaipito Stream.

On May 3, 1985, for example, flood conditions damaged 13 residential structures and five businesses (U.S. Army Corps of Engineers, Honolulu District, 1988).

More frequently, stormwater flows occasionally generate some flooding in the following areas:

- Pago Plaza parking lot;
- along the primary shoreline roadway between the culverts which drain stormwater into the inner Harbor; and,
- portions of the north side of Pago Park.

Using the results of stormwater modeling, hydraulic analyses, and a survey of existing culverts, PPC believes that localized flooding along portions of the primary shoreline roadway result from:

- some physical obstructions to culvert inlets and outlets;
- inadequate culvert sizes;
- debris and vegetation inside culverts that reduces culvert capacity; and,
- a general lack of regular culvert maintenance on a periodic basis.

Discharge of Sediments and Nutrients into the Inner Harbor

Sediment Inputs

Sediments are transported into inner Pago Pago Harbor during and following periods of heavier rainfall. The source of sediments is clearly soils in the upper watershed which are more susceptible to erosion. These include soils from the Fagasa family-Lithic Hapludolls-Rock Outcrop Association, as well as Aua very stony silty clay loam. Surface runoff carries eroded soil material into the six streams that are within the Vaipito Stream drainage.

Another cause of sedimentation is the hardening and narrowing of stream banks. Much of the existing stream channel contains basaltic rock; other portions of the channel consist of hardened soil material. Rock-filled, gabion baskets have also been installed along selected portions of Vaipito Stream to stabilize banks and to reclaim additional land area for adjoining residential sites. As hardened stream banks gradually collapse, more sediment is discharged into Vaipito Stream (Duffy, 1999).

The detention of surface runoff is needed to help reduce the amount of sediment that is discharged into inner Pago Pago Harbor via stormwater events. Potential detention areas in the lower watershed are limited. Most of the lower portions of the watershed are already urbanized by residential and commercial land uses. However, a detention opportunity is available in Pago Pago Harbor within open space areas as long as recreational opportunities are not eliminated.

In its modeling of the Vaipito Stream drainage, Pedersen Planning Consultants determined that a 2-year storm event generates a discharge of about 171 tons of sediment in the lagoon. Roughly 950 tons of sediment are generated by a potential 100-year storm event (Table 4-4).

TABLE 4-4
SEDIMENT CONTRIBUTION TO INNER PAGO PAGO HARBOR
2,10, 50, AND 100-YEAR STORM EVENTS
IN TONS PER STORM EVENT

Stream	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
Vaipito Stream	137	255	545	682
Unnamed Stream	31	58	123	154
Gagamoe Stream	3	5	11	14
All Streams	**171**	**318**	**679**	**850**

Source: Pedersen Planning Consultants, 1999

Nutrient Inputs

A 1984 study by CH2M Hill examined discharges from eight streams that discharge into Pago Pago Harbor. Three of these streams were located within the Vaipito Stream drainage: Vaipito Stream, Laolao Stream, and Aga Stream.

CH2M Hill estimated in 1984 that daily nutrient loading into Pago Pago Harbor included approximately 5,012 pounds of total Kjendahl nitrogen, 5,024 pounds of total nitrogen, and 500 pounds of phosphorus. The combined contribution of Vaipito, Laolao and Aga Stream was less than 0.3 percent of all nitrogen and phosphorus loading into Pago Pago Harbor (Table 4-5).

TABLE 4-5
NUTRIENT INPUTS INTO PAGO PAGO HARBOR
JULY, 1984 MEASUREMENTS

Source/Location	Total Kjeldahl Nitrogen (TKN) (mg/l)		Total (persulfate) Nitrogen (mg/l)		Total Phosphorus (mg/l)	
	Median	Percent Contribution	Median	Percent Contribution	Median	Percent Contribution
Vaipito Stream	0.980	0.18	1.023	0.19	0.127	0.23
Laolao Stream	1.160	0.01	1.395	0.02	0.122	0.01
Aga Stream	0.344	0.01	0.512	0.01	0.090	0.02
Other five streams discharg-ing to Harbor (combined)	5.696	0.15	8.557	0.25	2.441	0.87
Utulei WWTP	17.200	2.76	17.206	2.76	1.990	3.20
Tuna Canneries	871.000	96.89	871.000	96.77	90.300	95.67

Source: CH2M Hill, 1984

Marine Resources and Related Water Quality

Marine resources in the inner Harbor area are extremely limited due to cumulative, historical inputs of nutrients and sediments via discharges from local canneries, international cargo and fishing vessels, transient small craft, the Utulei WWTP, cesspool discharges, urban runoff, and local streams. The impact of these stresses upon water quality is exhibited, in part, by the lack of coral communities within the inner Harbor.

The significance of past nutrient and sediment discharges was exacerbated by the limited amount of water circulation within the inner Harbor. Such conditions hamper the net exchange of seawater from the outer Harbor area and the long-term recovery of coral communities.

Since the mid-1970's, the American Samoa Government, ASPA, and local canneries have expended considerable resources to improve the water quality of Pago Pago Harbor. Available data indicates that water quality in portions of Pago Pago Harbor has dramatically improved through a combination of cooperative efforts. However, improved water quality within the inner Harbor area has not generated any significant growth in coral colonization.
Despite the lack of coral communities, the inner Harbor area remains a popular area for recreational and subsistence fishing. This activity takes places primarily from the shoreline. However, a human risk assessment by EnviroSearch International in 1994 suggests a continuing health risk associated with the consumption of fish and shellfish from the inner Harbor.

Water Quality Standards

The surface water quality standards that are applicable to Pago Pago Harbor are summarized in Table 4-6.

TABLE 4-6
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO PAGO PAGO HARBOR

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	0.75	NTU
Total Phosphorus	30.00	microngrams per liter
Total Nitrogen	200.00	microngrams per liter
Chlorophyll a	1.00	microngrams per liter
Dissolved Oxygen	Not less than 70% saturation or less than 5.0 mgl. If the natural level of DO is less than 5.0 mgl, the natural level shall be the standard.	milligrams per liter
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

STORMWATER MANAGEMENT FACILITIES

Between Vaipito Stream and the north side of Pago Park, there are four culverts that permit the passage of stormwater runoff underneath the primary shoreline roadway in Pago Pago. These culverts include a variety of box and circular culverts that were constructed through the use of concrete and basaltic rock.

Condition and Deficiencies

A field survey of the four culverts in May, 1998 revealed that existing culverts are generally in good structural condition. Particular attention was given to Culverts P1 (Vaipito Stream) and P3, which enable the passage of stormwater flows via the unnamed ditch downstream of Pago Pago Elementary School. The physical deficiencies associated with each culvert are summarized in Table 4-7; culvert locations are depicted in Figure 4-3.

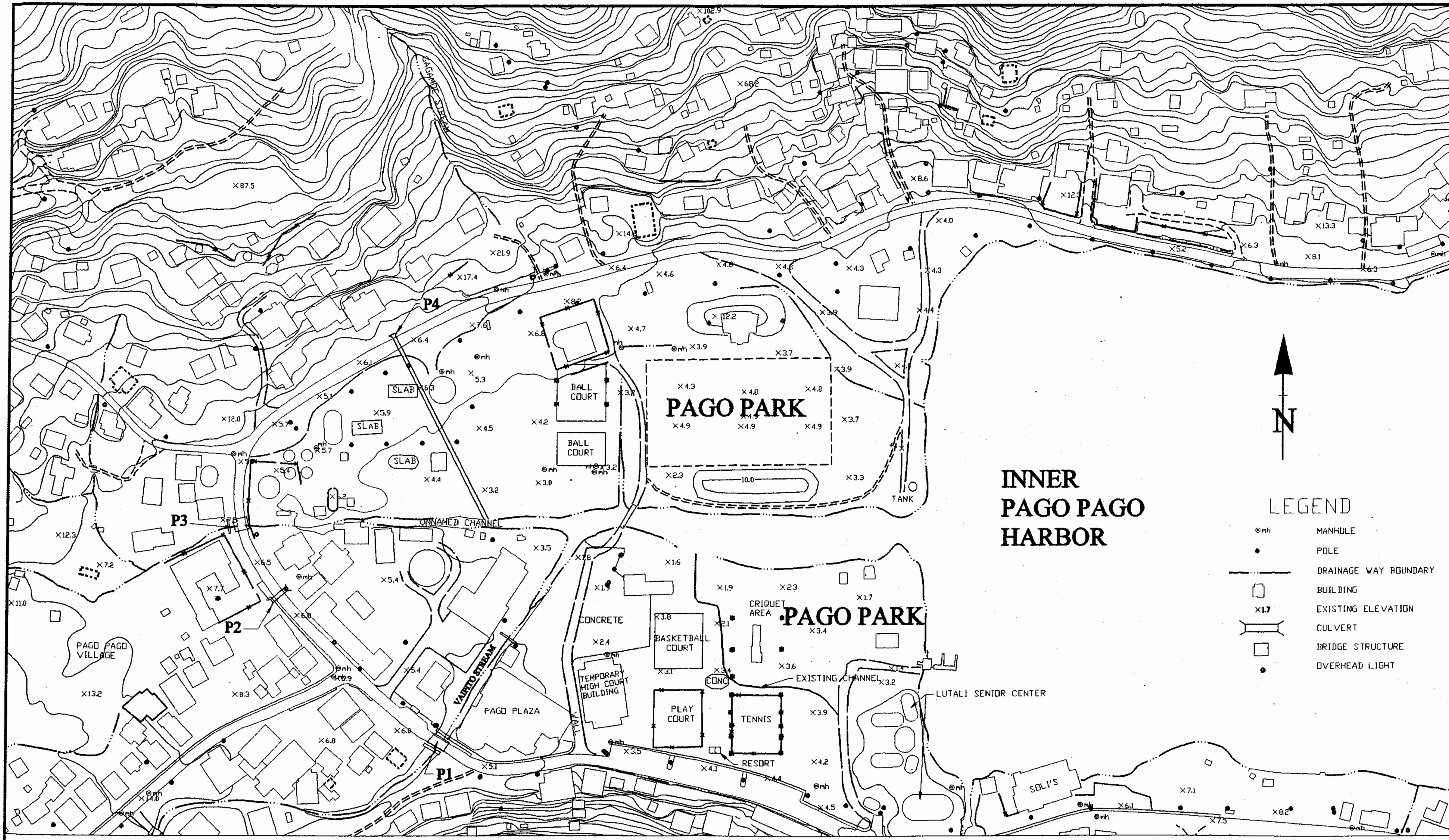
TABLE 4-7
STORMWATER CULVERTS
CONDITIONS, DEFICIENCIES, AND RECOMMENDED IMPROVEMENTS
MAY, 1998

Culvert Number	P1	P2	P3	P4
Size	13 x 5	3.5 x 3	17 x 4.5	3 diameter
Type	Box	Box	Box	Circular
Material	Concrete and basaltic rock	Concrete and basaltic rock	Concrete	Concrete
Condition	Good	Good	Good	Good
Required flow (CFS)	2,137	Varies with spill-over from P1 and P3	775	104
Deficiencies	Area for construction of new facilities is limited	Needs to be cleaned and maintained	I-beam collects debris and blocks channel	Size for amount of flow
Recommended improvements	Install a 13 x 5 culvert and maintain	Clean and maintain	Reconfigure structural supports for culvert, clean channel and culvert.	Clean existing 36" culvert, install a new 36" concrete culvert
Costs	Culvert *$45,550* Maintenance *1,500*	Maintenance *$1,500*	Culvert *$20,220* Maintenance *2,000*	Culvert *$24,150* Maintenance *2,000*
Subtotals	*$47,050*	*$1,500*	*$22,220*	*$26,150*
Contingencies (15%)	*7,058*	*0*	*3,333*	*3,923*
TOTAL	**$54,108**	**$1,500**	**$25,553**	**$30,073**

Source: Pedersen Planning Consultants, 1998

In May, 1998, these culverts were characterized by a significant amount of vegetation and debris. Regular periodic maintenance of each culvert is required to make effective use of the culverts and reduce flood potential along the primary shoreline roadway.

With regular maintenance, Culverts P1 and P3 are sized can accommodate stormwater flows generated from a 10-year storm. However, in the case of Culvert P3, an existing concrete I-beam underneath the primary shoreline roadway will need to be removed to achieve a 10-year storm capacity.



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Scale: 1" = 200'

LOWER VAIPITO STREAM DRAINAGE
EXISTING STORMWATER MANAGEMENT

Figure 4-3

Recommended Facility Improvements and Estimated Costs

It is recommended that proposed improvements to stormwater culverts along the primary shoreline roadway be limited to the removal of a concrete I-beam in Culvert P3. Removal of this obstruction is estimated to cost approximately $500.

Recommended Maintenance of Stormwater Culverts

Regular periodic maintenance of stormwater Culverts P1 through P4 between Vaitele Stream and Amaile Stream is required to reduce localized flooding and the number of emergency responses by ASG Public Works personnel to clear blocked stormwater culverts (Figure 4-4). The maintenance of Culvert P2 is particularly important because this conveyance structure provides an overflow for Culvert P3.

It is recommended that a three-person crew be organized by the ASG Department of Public Works to maintain these culverts, at least, four times per year. This crew should remove vegetation, garbage, and other debris that reduce the flow of stormwater discharges into culvert inlets and outlets. Such maintenance should extend along each of the 13 stream courses approximately 50 feet upstream and 50 feet downstream of culvert inlets and outlets, as well as inside the culverts that pass underneath the roadway.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes that can be used to clear vegetation;
- sledge hammers, picks, shovels, and rakes that can be used to remove obstructions and debris from stream course areas immediately adjacent to culvert inlets and outlets;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose that can be used to clear debris inside closed culverts; and, small truck to haul collected solid waste material and garbage from each stream course and culvert.

STORMWATER DETENTION OPPORTUNITIES

The north side of Pago Park offers some potential for stormwater detention (Figure 4-4). Existing land uses, which are adjacent to the lower reaches of Vaipito Stream, limit the amount of lands that could potentially be devoted to this purpose.

Pago Park

Site Location

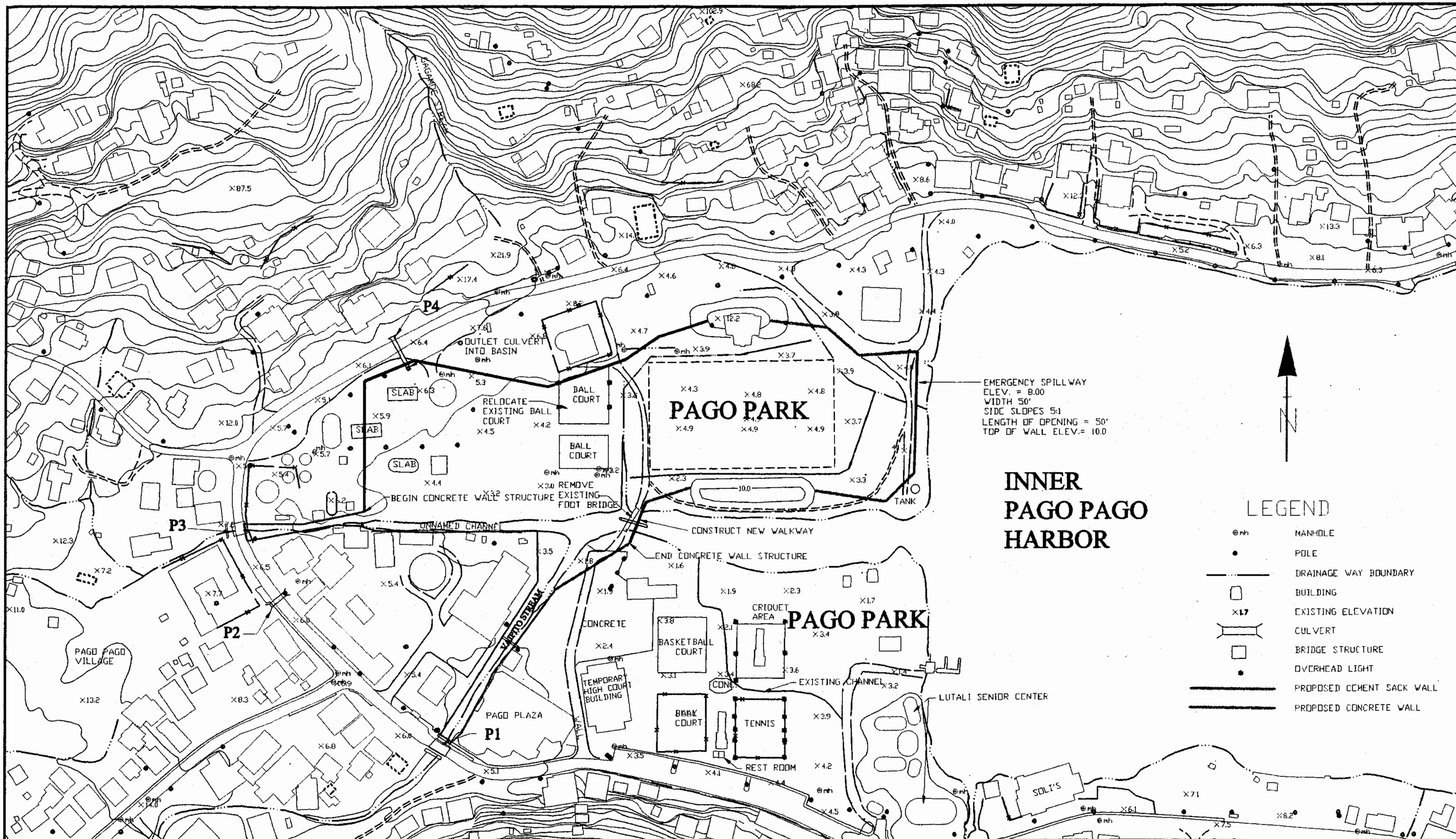
Pago Park is located at the head of Pago Pago Harbor between the shoreline and the primary shoreline roadway. The park is bisected by the lower Vaipito Stream drainage.

North Side of Park

The north side of the Park, which ranges between 3 and 6 feet above mean sea level, is relatively flat. This portion of the Park contains an open grassy area, which is used for informal soccer games and other general recreation. Two basketball courts are located on the west side of the open grassy area.

Abandoned concrete slabs are situated on the west side of the Park. Pedestrian access to the south side of the Park is available via a small wooden bridge across Vaipito Stream.

Two single family residences are located immediately adjacent to the north and west sides of the Park. The abandoned Korea House, which was formerly damaged by fire, lies just northeast of Pago Park.



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Scale: 1" = 200'

LOWER VAIPITO STREAM DRAINAGE
PROPOSED STORMWATER MANAGEMENT
Figure 4-4

South Side of Park

The south side of the Park includes courts for tennis, basketball, cricket, and general recreation.

This area is relatively flat with a general slope toward Vaipito Stream. Ground elevations range between 1.6 and 6.3 feet above mean sea level. A small man-made drainage ditch meanders through the south side of the Park from the east side of the Lutali Senior Center to the south side of Vaipito Stream.

General Design Concept

A proposed detention area would be developed on the north side of Pago Park through the excavation of approximately 2.0 acres of land to about the 4-foot contour (Figure 4-4). In essence, roughly 2,500 cubic yards of soil would initially be removed from the detention area.

A five to six-foot high wall would be constructed along the perimeter of the detention pond, which would extend approximately 2,700 feet. The wall would be constructed through the use of small bags of cement that would be hand-carried and placed along the pond perimeter. The maximum side slope of the wall would contain a 4:1 slope.

New swales would be constructed within the detention area which would help direct stormwater flows to the proposed detention area outlet. Because of the proximity of the water table, it is possible that lands within the proposed detention area may become more wet. Despite some increased moisture in the area, it is believed that the area will remain capable of supporting a variety of outdoor recreational activities.

The wall of the detention area would be back-filled with native soil to reduce the visual impact of the concrete bags. Selected landscape materials would be planted along the outside of the pond perimeter to further enhance the attractiveness of the detention area. It is envisioned that landscaping would be accomplished by ASEPA and ASCC Land Grant Program.

In order to maintain recreational opportunities to Pago Pago and other residents of Tutuila, the proposed detention area would be accessible for general recreation. Open area and courts inside the detention pond would be available for soccer, general play, and basketball. However, one of the two basketball courts would require relocation to the west side of the Park. A new walkway would be constructed across Vaipito Stream to enable continued access to the south side of the Park.

Project Development Costs

Construction of the detention pond would cost roughly $1.2 million (Table 4-8). Based upon information gained from local contractors in American Samoa, it is believed that roughly 40 percent of the construction cost would reflect the cost of excavation and the construction of the wall around the pond perimeter.

The cost associated with the importation of top soil around the exterior of the pond perimeter could be significantly reduced through the importation of soil material from the proposed detention pond along Sauino Stream in Nuuuli. It is estimated that this approach would reduce topsoil importation costs to approximately $154,000. If the Vaipito Stream project would be scheduled to facilitate the reuse of excavated soils from the Nuuuli project along Sauino Stream, a potential savings of $358,500 could be realized and reduce the overall project cost to roughly $824,850.

TABLE 4-8
ORDER-OF-MAGNITUDE COST ESTIMATE
CONSTRUCTION OF DETENTION POND
ON THE NORTH SIDE OF PAGO PARK

Item	Unit Cost	Quantity	Extension ($)
Mobilization	Lump Sum	1	$ 5,000
Relocate basketball court	$5/square foot	12,000	60,000
Excavation	$5/Cubic Yard	2,500	12,500
Perimeter wall construction (sacks of cement)	$150/Linear Foot	2,700	405,000
Top soil	$25/Square Yard	20,500	512,500
Outlets	$5,000/Each	3	15,000
Pedestrian walkway & dam	$200/Linear Foot	95	19,000
		Subtotal	*$1,029,000*
		15% Contingency	*154,350*
		TOTAL	**$1,183,350**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

If constructed, a detention pond facility in this area could provide some nominal reduction in the amount of sediment that otherwise would be discharged into the inner Harbor (Table 4-9). Roughly 152 tons of sediment could be detained from a 2-year storm event. Some 705 tons of sediment would be detained from a 100-year storm event.

TABLE 4-9
POTENTIAL SEDIMENT DETENTION
ACHIEVED VIA CONSTRUCTION OF DETENTION POND
ON THE NORTH SIDE OF PAGO PARK
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
152	275	568	705

Source: Pedersen Planning Consultants, 1999

A reduction in flooding within the Pago Plaza parking area would occur with the establishment of the detention pond.

Recreational opportunities in Pago Park would be maintained on the north and south sides of the Park. Outdoor recreation within the detention pond could take place even with the establishment of the detention pond.

CHAPTER SIX
TULA WATERSHED

STUDY AREA LOCATION

The Tula watershed planning area, which is defined by natural resource managers in American Samoa and the American Samoa Watershed Protection Plan, includes approximately 0.6 square mile of land area (Figure 6-1) along the northeast tip of Tutuila. Within this area, there are three streams.

STUDY OBJECTIVE

This stormwater evaluation focuses upon potential opportunities for the detention of stormwater runoff and sedimentation within a wetland on the north side of Tula Village. The draft Watershed Protection Plan points out a need for a more detailed evaluation of this opportunity to determine viable stormwater management improvements that will:

- reduce the discharge of sediments into the nearshore waters seaward of Tula Village and improve nearshore water quality; and,
- reduce flooding within the inhabited village area.

HYDROLOGY

General Drainage Characteristics

Stream Discharges

Vailoa Stream and its four tributaries represent the primary drainage in the watershed (Figure 6-1). This stream, which drains the east slopes Lefutu Ridge and the north slopes of Maugaleoo Ridge, passes through portions of the inhabited village area. A man-made swale transports surface runoff through the west side of the Village and, eventually, connects to a defined stream channel on the north side of Tula. Vailoa Stream discharges along the shoreline approximately 750 feet north of Tula Elementary School.

Maupua Stream drains the north side of Lefutu Ridge and the east side of Lefao Ridge (Figure 6-1). This stream, which extends approximately 850 feet in length, discharges along the shoreline of the north side of the Tula watershed planning area, but does not drain within the inhabited village area.

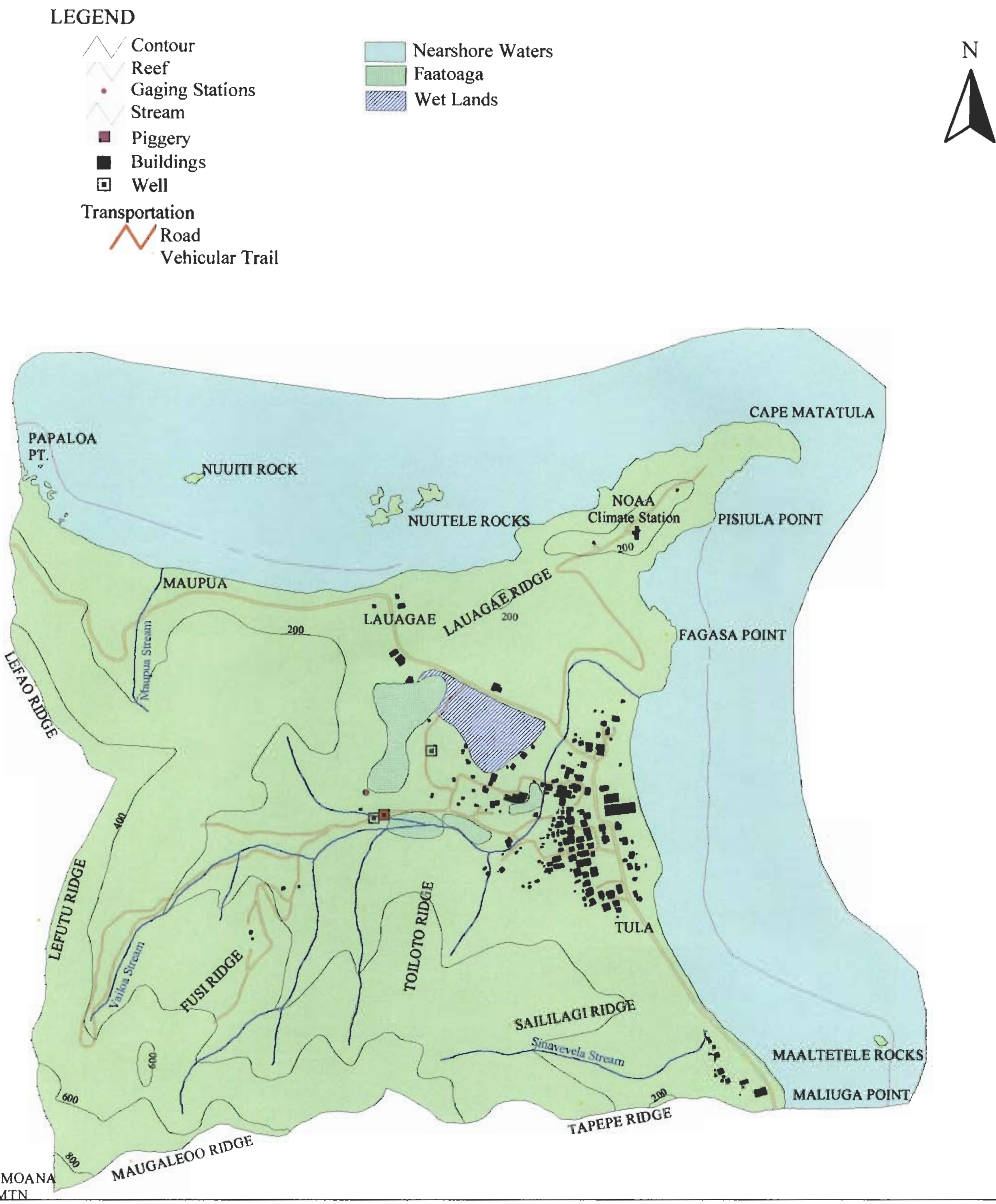
Sinavevela Stream drains Saililagi Ridge and Tapepe Ridge, as well as the east slope of Maugaleoo Ridge (Figure 6-1). This stream discharges immediately upland of a few homes on the southeast side of the watershed planning area.

Stream Flows

In 1996, the U.S. Geological Survey estimated the median stream flow for Vailoa Stream to be 0.02 cubic feet per second (Wong, 1996). This estimate was based, in part, upon nine intermittent stream flow measurements made by the U.S. Geological Survey between 1958 and 1965.

Wetlands

A ruderal, fresh-water wetland is situated on the north side of Tula Village (Figure 6-2) and east of the primary shoreline roadway (Biosystems Analysis, Inc., 1992). The wetland comprised approximately 8 acres of land in 1992. Biosystems Analysis reported that the wetland was primarily an herbaceous marsh. In 1976, Whistler reported that the area was a former coastal marsh.



American Samoa Geographical Information System

0.25 0 0.25 0.5

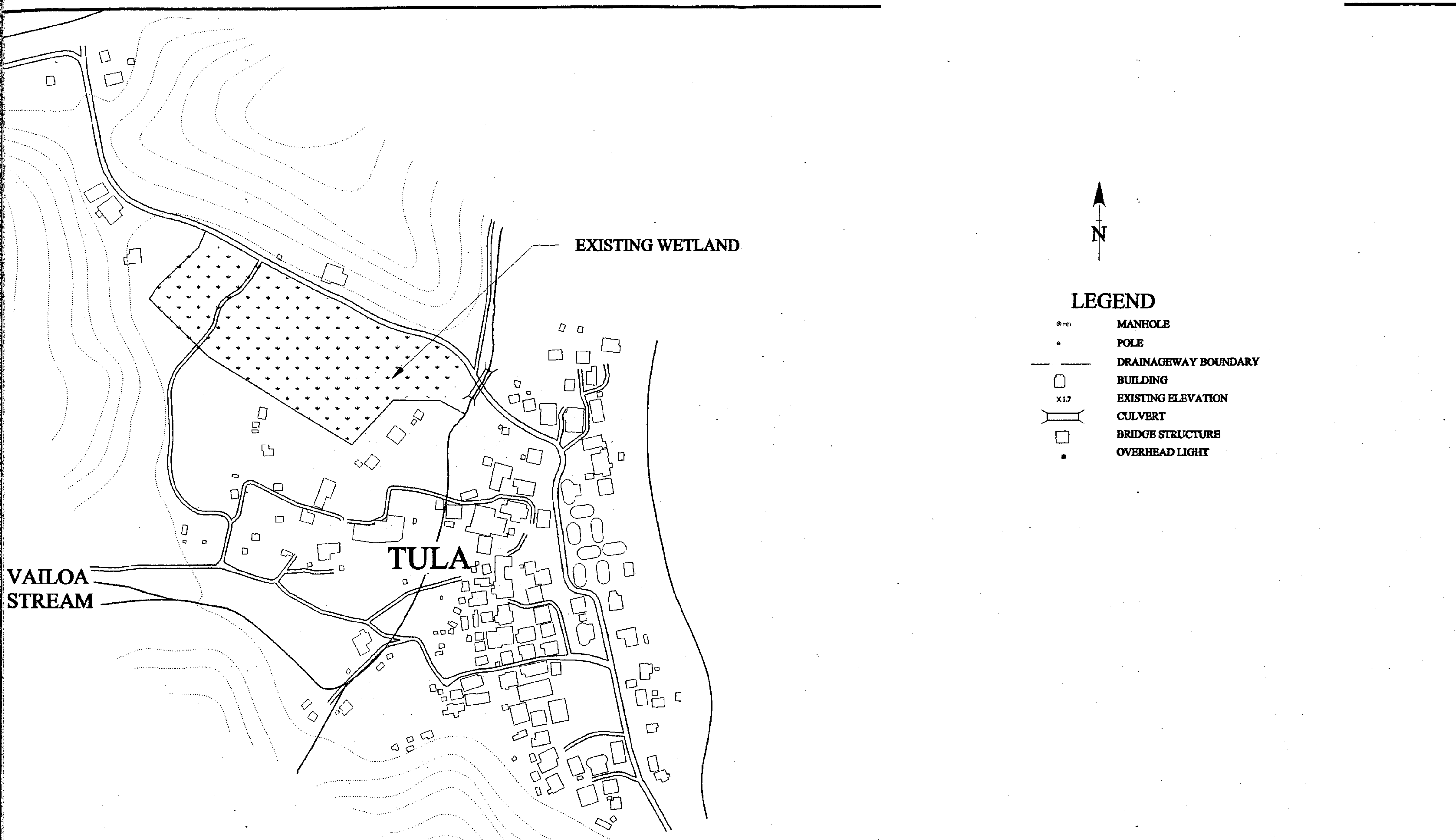
Miles
Scale 1:12,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Tula Watershed

Existing Conditions

Figure 6-1



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TULA STORMWATER MANAGEMENT

Scale: NOT TO SCALE

Figure 6-2

Between 1992 and 1998, some filling of the wetland has occurred that has reduced the size of the wetland. In May, 1998, Pedersen Planning Consultants observed the use of copra and some smaller basaltic fill material to apparently establish a flat land area for a possible recreational or residential site on the north side of the wetland, as well as some limited planting of coconut. In 1996, PPC previously documented a significant amount of garbage stored in the northeast corner of the wetland; however, this solid waste material was not observed in May, 1998.

The wetland receives surface runoff via overland flows from upland slopes south and west of the wetland. Along the north side of the wetland, two 4 x 8-foot culverts underneath the primary shoreline roadway enable the transport of some surface runoff from upland slopes adjacent to the northeast corner of the wetland.

Field observations by PPC in May, 1998 found no surface connections between Vailoa Stream and/or the man-made swale through the village to the wetland. Some surface connection to the Vailoa Stream drainage (including man-made swale) would be necessary if the wetland is to detain the primary source of stormwater flows in Tula.

Stormwater Runoff

U.S. Army Corps of Engineer Estimates

A flood insurance study was published by the Federal Emergency Management Agency (FEMA) in May, 1991. This study included flood risk data for selected areas on the Island of Tutuila that were intended to:

- facilitate the establishment of actuarial flood insurance rates; as well as,
- provide information that could be used for local floodplain management efforts in American Samoa.

The U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses in 1987 that supported the FEMA study. This study included an analyses of Vailoa Stream and the calculation of 100-year peak discharges at two points along this stream (Table 6-1).

TABLE 6-1
ESTIMATED 100-YEAR PEAK DISCHARGES
VAILOA STREAM

Stream	Location	Drainage Area (square miles)	100-Year Peak Discharge (cfs)
Vailoa	stream mouth	0.29	1,230
	approx. 1,800 feet upstream of stream mouth	0.24	1,040

Source: Federal Emergency Management Agency, 1991

Computer Modeling of Potential Stormwater Detention Area

The Tula wetland (Figure 6-2) provides a potential opportunity to detain some stormwater runoff from Vailoa Stream, as well as adjacent upland slopes. In light of this opportunity, Pedersen Planning Consultants modeled potential discharges of surface runoff into this wetland for 2, 10, 50, and 100-year storm events.

The computer modeling of potential stormwater events suggests that potential stormwater flows to the Tula wetland range between 244 cubic feet per second (cfs) for a 2-year storm event and 944 cfs for a 100-year storm (Table 6-2).

TABLE 6-2
STORMWATER RUNOFF DISCHARGES INTO TULA WETLAND
2,10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
All Surface Runoff	244	465	735	944

Source: Pedersen Planning Consultants, 1998

In the modeling of surface runoff, it was assumed that the wetland would be able to hold an average depth of approximately four feet of runoff. To achieve such depth, the wetland would need to be excavated approximately four feet. In addition, an impermeable structure would need to be constructed around the perimeter of the wetland.

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding

Flood insurance rate maps, which were developed by FEMA in 1991, suggest that there is inland flood potential in the following areas:

- the Tula wetland;
- the east and west sides of the inhabited village area.

West Side of Tula Village

The west side of Tula Village is occasionally flooded by uncontained surface flows from the Vailoa Stream drainage. A survey of selected portions of the drainage indicate that higher stormwater flows have historically formed a deep, narrow stream channel near the confluence of Vailoa Stream's main stem and three tributaries. This suggests the transport of fast moving stormwater during higher stormwater events.

During and immediately following higher stormwater events, it is suspected that stormwater flows occasionally overtop the existing stream channel. Overland flows likely flow downslope to an adjoining banana plantation, the man-made swale, and/or flood portions of the less-developed, upper village area.

North of the confluence of Vailoa Stream's main stem and three tributaries, overland flows from upland slopes also generate some flooding. The lack of defined channels and presence of dirt and cinder vehicular trails leads some of the surface runoff to flood and erode these trails. In addition, predominant Fagasa Family-Lithic-Hapludolls soils and Aua very stony silty clay loam soils have a potential for rapid runoff because of their silty clay loam composition. A portion of the overland flow drains into the Tula wetland.

East Side of Tula Village

The east side of Tula Village, which is generally downslope of the man-made swale through the village, also experiences occasional flooding. However, such flooding probably occurs in conjunction with less frequent hurricanes and higher stormwave periods.

Some flooding may also occur during and following higher stormwater events when stormwater flows through the man-made swale exceed the capacity. These potential conditions should be confirmed through informal discussions with local village residents.

Sedimentation

The sedimentation of local streams occurs is typically generated during and following heavier rainfall events. Sediments usually accompany stormwater runoff that is discharged from local streams and steeper upland slopes.

The source of sediments being discharged into local streams is derived from more erosive soils along the upper slopes of the Vatia watershed. These include soils from the Fagasa family-Lithic Hapludolls-Rock Outcrop Association, as well as Aua very stony silty clay loam. Surface runoff carries eroded soil material into Vailoa Stream and its four tributaries.

The discharge of sediments into the Vailoa Stream drainage ultimately discharge into the nearshore waters seaward of Tula Village. Significant turbidity and sedimentation generally do not promote long-term nutrition, growth, reproduction, and depth distribution of nearshore coral communities (Richmond, 1993).

PPC's modeling of various storm events suggest that sediment discharges from Vailoa Stream ranges from approximately 45 tons of sediment from a 2-year storm to roughly 203 tons that is generated from a 100-year storm event. While the Tula wetland provides an opportunity for the deposition of sediments, long-term sediment accumulation and the filling of this wetland by local residents has gradually reduced the capacity of the Tula wetlands to detain stormwater runoff.

The detention of surface runoff is needed to help reduce the amount of sediment that is discharged into the nearshore waters via stormwater events.

Marine Resources and Related Water Quality

The width of the fringing reef seaward of Tula Village is highly variable. Between Cape Matatula and Maliuga Point, the width of the reef extends between 200 and 1,100 feet.

The reef front of the fringing coral reef has not been surveyed by marine biologists since 1978 and 1979. During this period, marine ecologists devoted considerable attention to a crown-of-thorns starfish infestation that significantly impacted nearshore coral communities along various parts of the Island of Tutuila.

In the vicinity of Cape Matatula, living corals were observed at depths of 6 to 33 feet in August and September, 1979. However, the crown-of-thorns starfish was uncommon in this area.

Along the forereef slopes seaward of Tula Village, no infestation by the crown-of-thorns starfish was documented in mid-1978. By August/September, 1979, the starfish was sparse along the upper reef front (at depths of 6 to 33 feet) where 70 percent of the coral heads were alive.

The reef provides significant habitat to fishes and other marine organisms. A reduction of turbid stormwater runoff and sediment discharges will help maintain the health of the fringing coral reef communities and promote future growth. Corals are dependent upon the availability of light and related photosynthesis.

Adequate nearshore water quality also impacts the lifestyle and diet of local village residents. A number of residents regularly use the nearshore waters for subsistence and recreational fishing. A 30-year resident of Tula indicates that about 20 to 30 people per day use the nearshore waters for fishing on weekdays. However, weekend fishing activity decreases to about 10 persons per day (Haro, 1996).

Water Quality Standards

American Samoa's surface water quality standards, which are applicable the nearshore waters seaward of Tula Village, are water quality criteria for "open coastal waters". These water quality standards were most recently revised in 1989 and are summarized in Table 6-3.

TABLE 6-3
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO THE NEARSHORE WATERS
SEAWARD OF TULA VILLAGE

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	0.25	NTU
Total Phosphorus	15.00	microngrams per liter
Total Nitrogen	130.00	microngrams per liter
Chlorophyll a	0.25	microngrams per liter
Dissolved Oxygen	Not less than 80% saturation or less than 5.5 mgl. If the natural level of DO is less than 5.5 mgl, the natural level shall be the standard.	milligrams per liter
Light Penetration Depth	Exceed 130 feet 50% of the time.	feet
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

STORMWATER MANAGEMENT FACILITIES

There are two stormwater culverts along the primary roadway that are relevant to the evaluation of stormwater detention opportunities.

Culvert T1 is located at the intersection of the Vailoa Stream and the primary shoreline roadway. This facility is a triple culvert conveyance structure that was constructed with concrete. Each culvert is 8x4.5-feet high and 36 feet long. This conveyance structure was installed during the recent reconstruction of the Tula-Onenoa Road. In May, 1998 its structural condition appeared to be in excellent condition. This facility is adequate to accommodate a stormwater flow from a 50-year storm event.

Culvert T2 is a double culvert located 200-300 feet northwest of Culvert T1. Two 4x8-foot culverts are located underneath the primary shoreline roadway and direct drainage from the north side of the road into the Tula wetland. This facility, which was also constructed during the reconstruction of the Tula-Onenoa Road, was in good structural condition in May, 1998. The culverts can accommodate stormwater flows roughly equal to 50-year storm events.

Recommended Facility Improvements

In light of the structural condition and capacity of Culverts T1 and T2, no facility improvements are believed to be necessary.

Recommended Maintenance of Stormwater Culverts

Regular periodic maintenance of stormwater Culverts T1 and T2 is required to reduce potential localized flooding and emergency responses by public works personnel.

It is recommended that a three-person crew be organized by the ASG Department of Public Works to maintain these culverts, at least, four times per year. This crew should remove vegetation, garbage, and other debris that reduce the flow of stormwater discharges through culverts. Such maintenance should extend along each of the six stream courses or wetlands approximately 50 feet upstream and 50 feet downstream of culvert inlets and outlets, as well as inside the culverts.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes that can be used to clear vegetation;
- sledge hammers, picks, shovels, and rakes that can be used to remove obstructions and debris from stream course areas immediately adjacent to culvert inlets and outlets;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose that can be used to clear debris inside closed culverts; and,
- small truck to haul collected solid waste material and garbage from stream courses and culverts.

STORMWATER DETENTION OPPORTUNITY

The Tula wetland represents a potential stormwater detention opportunity. However, any alteration of this wetland to accommodate greater stormwater detention requires the development of a hydrologic connection to Vailoa Stream. In the absence of this connection, the amount of detention that could be achieved by the wetland would be limited.

Based upon field observations in May, 1998, it is suspected that higher stormwater flows upslope of the village are very rapid near the confluence of Vailoa Stream's main stem and three tributaries. The energy associated with stormwater flows will also need to be dissipated to direct stormwater flows to the wetland via a drainage channel.

Site Location

The proposed stormwater management improvements would be made within the lower Vailoa Stream drainage (Figure 6-3). A proposed drainage channel and energy dissipators would be located on the west side of Tula Village. The proposed detention area would include the 8-acre wetland on the north side of Tula Village, as well as an adjacent 1.4 acres that is part of the Vailoa Stream drainage (Figure 6-3).

General Design Concept

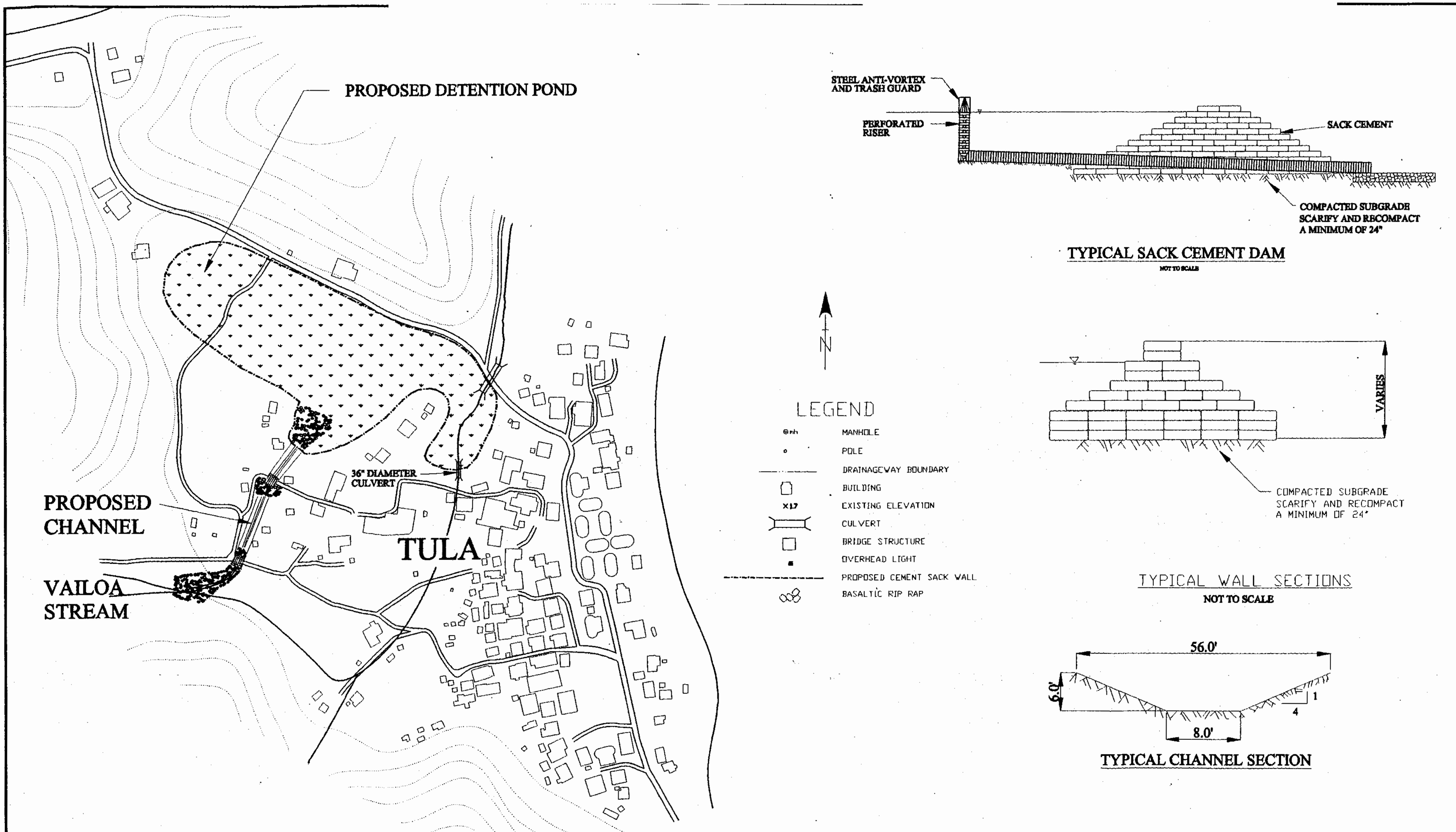
The objective of the proposed conceptual design is to:

- reduce flooding and potential property damage along the west side of Tula Village;
- direct almost all stormwater flows from the Vailoa Stream drainage into the Tula wetland;
- detain stormwater flows from stormwater events to permit the settlement of sediments carried by stormwater flows;
- expand the size of the existing wetland and connect the wetland to the Vailoa Stream drainage; and,
- use Vailoa Stream as an outlet for stormwater discharges to the nearshore waters.

To accomplish these objectives, a new earth-lined channel would be constructed on the west side of Tula Village. A 500-foot long channel would extend from the confluence of Vailoa Stream's main stem and three tributaries to the Tula wetland. Basaltic rock will be used to line the channel at points here the potential for erosion is likely, e.g., inlets and outlets. Pre-fabricated concrete dissipators would be placed at selected points along the channel to slow the rate of stream discharge.

The existing wetland would be excavated and expanded to include an additional 1.0-acre on the northeast side of the wetland. The expanded wetland would accommodate anticipated 100-year storm discharges. The wetland would be excavated to a depth of approximately three feet above sea level.

A nominal slope toward the east side of the wetland will be made to ensure a slower flow of stormwater to an existing culvert (T1) along Vailoa Stream that is situated underneath the primary shoreline roadway.



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TULA DETENTION/SEDIMENT POND AND RELATED CHANNEL

Scale: NOT TO SCALE

Figure 6-3

A five to six-foot high wall would be constructed along the perimeter of the expanded wetland. The wall would be constructed through the use of small bags of cement that would be hand-carried and placed along the pond perimeter. The maximum side slope of the wall would contain a 4:1 slope.

A culvert would also be installed within the southeast corner of the wall structure to enable the collection and discharge of stream discharges from the existing man-made channel through west side of Tula Village. Existing culvert T1 would serve as the outlet from the detention area where overflows would discharge into the lower end of Vailoa Stream.

The wall would be back-filled with native soil to reduce the visual impact of the concrete bags. Selected landscape materials would be planted along the outside of the pond perimeter to further enhance the attractiveness of the detention area. Landscaping around the perimeter of the detention pond would be accomplished by ASEPA and ASCC Land Grant Program.

Project Development Costs

Construction of the proposed channel and energy dissipators and a detention pond would cost roughly $327,750 (Table 6-4).

TABLE 6-4
ORDER-OF-MAGNITUDE COST ESTIMATE
DEVELOPMENT OF CHANNEL AND DETENTION POND
IN VAILOA STREAM DRAINAGE AND TULA WETLAND

Item	Unit Cost	Quantity	Extension
Mobilization	Lump Sum	1	$ 5,000
Excavation	$5/Cubic Yard	5,000	25,000
Channel Construction	$50/LF	860	43,000
Berm Construction	$100/Linear Foot	1,850	185,000
New Outlets	$5,000/Each	3	15,000
Culvert Along Vailoa Stream	$325/LF	1	9,750
Clean Existing Culverts	Lump Sum	1	2,000
Road Crossings	$5,000/Each	2	10,000
		Subtotal	*$294,750*
		15% Contingency	*44.213*
		TOTAL	**$338,963**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

If the proposed stormwater facilities were constructed, a reduction in localized flooding would occur on the west side of Tula Village.

A detention pond facility in the Tula wetland would provide a reduction in the amount of sediment that would otherwise be discharged into the nearshore waters seaward of Tula Village (Table 6-5). Roughly 42 tons of sediment could be detained from a 2-year storm event. Some 179 tons of sediment would be detained from a 100-year storm event.

TABLE 6-5
POTENTIAL SEDIMENT RETENTION
ACHIEVED VIA CONSTRUCTION OF DETENTION POND
WITHIN TULA WETLAND
IN TONS OF SEDIMENT PER STORM EVENT

2-Year Storm	10-Year Storm	50-Year Storm	100-Year Storm
42	84	136	179

Source: Pedersen Planning Consultants, 1999

CHAPTER SEVEN
LEONE WATERSHED

STUDY AREA LOCATION

The Leone watershed planning area, which is defined by natural resource managers in American Samoa and the American Samoa Watershed Protection Plan, includes approximately 5.7 square miles of land area (Figure 7-1). There are approximately five primary drainage areas in this watershed planning area.

The drainage area considered in this stormwater evaluation is Leafu Stream. This drainage is situated near the center of the Leone watershed planning area and is located west of Malaloto Ridge and Lesui Ridge.

STUDY OBJECTIVE

This stormwater evaluation focused exclusively upon the stormwater runoff from Leafu Stream and the downstream discharges into Leone Pala and the nearshore waters of Leone Bay. The feasibility and value of potential stormwater management opportunities were examined to determine viable improvements that will:

- reduce the discharge of sediments into Leone Pala;
- reduce flooding within residential areas adjacent tot Leafu Stream; and,
- enhance and restore selected hydrologic characteristics of Leafu Stream.

HYDROLOGY

Leafu Stream Drainage

Leafu Stream and its three branches drain surface runoff from approximately 875 acres, or approximately 1.37 square miles of land area. The main branch of this stream extends up to approximately 1,135 feet above mean sea level. The upper elevation of the drainage is located upslope of the southwest side of Aoloaufau Village (Figure 7-2).

Surface flows from Aualii Stream, which drains runoff between Tutu Ridge and Mulimauga Ridge, also discharge into Leone Pala. These surface flows ultimately discharge into the nearshore waters of Leone Bay at the mouth of Leafu Stream.

Stream Flows

In 1996, the U.S. Geological Survey estimated generally comparable rates of median stream flow for two locations along Leafu Stream (Table 7-1). These estimates were based upon continuous and partial gage measurements of stream flow by the U.S. Geological Survey.

TABLE 7-1
MEDIAN STREAM FLOW ESTIMATES
STREAMS IN THE LEAFU STREAM DRAINAGE

Stream	USGS Gage Station	Gage Location	Stream Flow Measurements (number)	Estimated Median Flow (cfs)
Leafu Stream	16934000	0.9 mile upstream from stream mouth; 30 feet upstream of reservoir	36	2.61
Leafu Stream	169335000	1.3 miles NE of Leone; 900 feet upstream of village intake	continuous Oct,1977-Sept, 1986; 5 between 1987-1990	2.50

Source: Wong, 1996.

American Samoa Geographical Information System

0.5 0 0.5 1 1.5

Miles

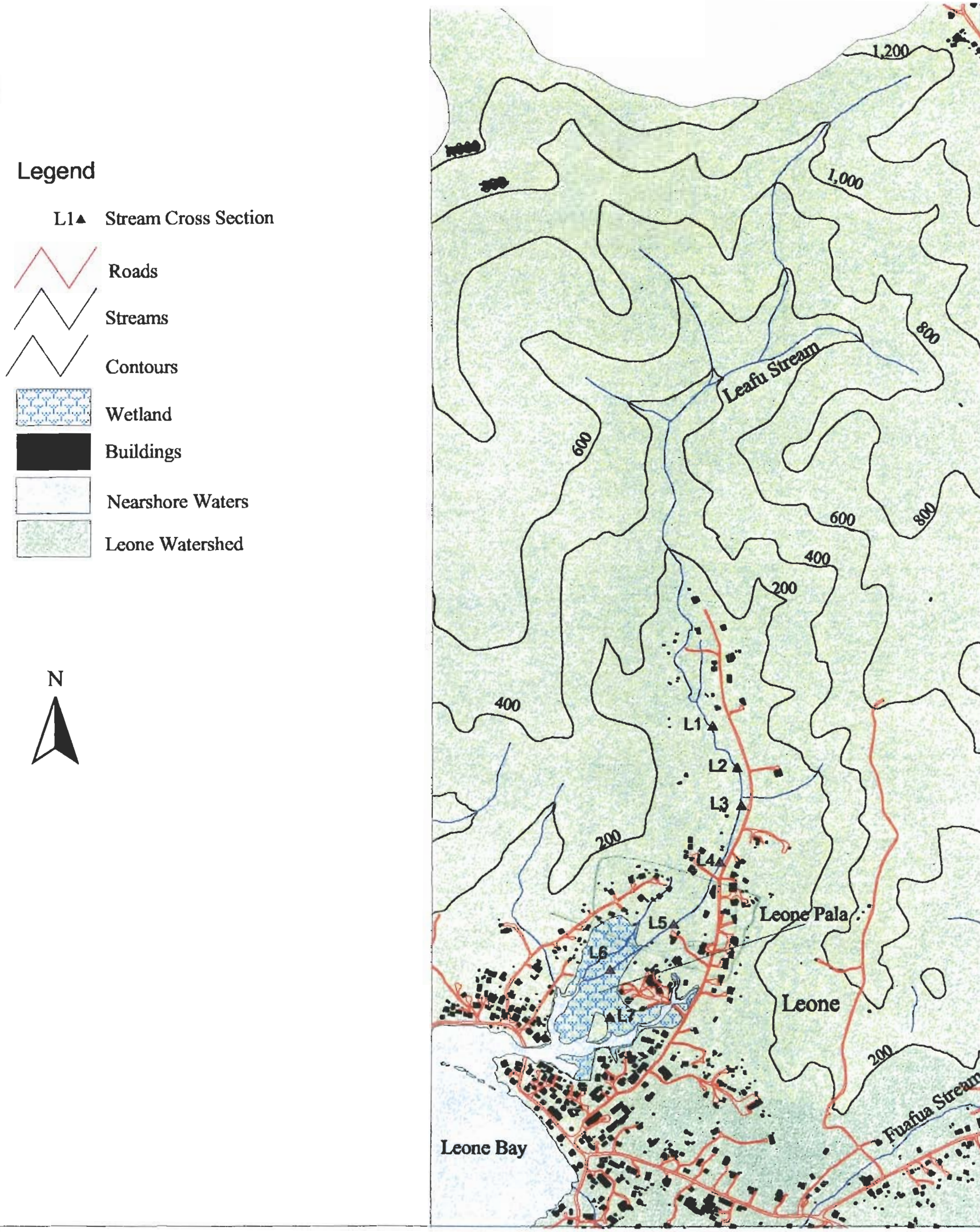
Scale: 1:32,000

Prepared by: Pedersen Planning Consultants Tel: 307-327-5434

Leone Watershed

Existing Conditions

Figure 7-1



American Samoa Geographical Information System

Not to Scale

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Leafu Stream Drainage

Figure 7-2

However, during and following heavier rainfall events, stream flow discharges along Leafu Stream are significantly greater. For example, a maximum discharge of 400 cfs at station 169335000 was recorded by USGS on December 3, 1984.

Stormwater Runoff

Stormwater runoff discharges into downstream Leone Pala are primarily generated from heavier rainfall events that occur within the Leafu Stream drainage. Computer modeling of the Leafu Stream drainage by Pedersen Planning Consultants suggests potential stormwater flows range between 2,350 cubic feet per second (cfs) for a 10-year storm event and 4,098 cfs for a 100-year storm.

TABLE 7-2
STORMWATER RUNOFF DISCHARGES INTO LEONE PALA
10,50, AND 100-YEAR STORM EVENTS
IN CUBIC FEET PER SECOND (CFS)

Location	10-Year Storm	50-Year Storm	100-Year Storm
Leafu Stream Mouth	2,350	3,684	4,098

Source: Pedersen Planning Consultants, 1998

Stream slopes in the lower Leafu Stream drainage range from less than 0.5 percent to greater than 2.0 percent.

Correlation with Other Stormwater Runoff Estimates

A flood insurance study was published by the Federal Emergency Management Agency (FEMA) in May, 1991. This study included flood risk data for selected areas on the Island of Tutuila that were intended to:

- facilitate the establishment of actuarial flood insurance rates; as well as,
- provide information that could be used for local floodplain management efforts in American Samoa.

The U.S. Army Corps of Engineers completed hydrologic and hydraulic analyses in 1987 that supported the FEMA study. The 100-year peak discharges calculated for the streams that drain into Leone Pala were somewhat less than those determined by Pedersen Planning Consultants in 1998 (Table 7-2 and Table 7-3). The U.S. Army Corps of Engineer estimates were about 22 percent less than the 100-year flows calculated by PPC for the Leafu Stream. The difference in estimated stormwater flows results from the use of different methodologies.

TABLE 7-3
U.S. ARMY CORPS OF ENGINEER ESTIMATES
100-YEAR STORMWATER FLOW
LEAFU STREAM DRAINAGE

Flooding Source and Location		Drainage Area (Square Miles)	100-Year Peak Discharge (cubic feet per second or cfs)
Leafu Stream	At mouth	1.45	3,210
	Above confluence with Aualii Stream	1.25	2,880
	Below confluence with unnamed tributary	1.13	2,680
	Upstream limit	1.00	2,430

Source: Federal Emergency Management Agency (FEMA), 1991

OVERVIEW OF STORMWATER MANAGEMENT ISSUES

Flooding Along Inland Roadway and Adjoining Residential Area

Localized flooding occurs within selected residential areas adjoining Leafu Stream during and following heavier rainfall events. The residential area adjacent to the lower portion of Leafu Stream is situated below the 100-foot contour.

Stormwater flows in this area typically pond on portions of the inland roadway that is situated east of Leafu Stream. Heavier rainfall events also flood some residential properties on the east and west sides of Leafu Stream.

These conditions are believed to generate primarily from shallow stream depths along the lower reaches of Leafu Stream. During May, 1998, PPC observed and/or measured stream cross-sections at several locations along Leafu Stream. Stream depths generally ranged between 2.0 and 9.0 feet. In contrast, the measurements at station L6 indicated little or no channel depth within a wide undefined drainageway.

TABLE 7-4
MEASUREMENTS FROM SELECTED STREAM CROSS SECTIONS, LEAFU STREAM
MAY, 1998

Station	Channel Width (from top of bank in feet)	Width of Channel Bottom (feet)	Channel Depth (feet)	Other Characteristics
L1	N/A	N/A	9	9-year resident reports stream flows remain within stream banks
L2	20	10	5	Medium rock along bottom
L3	15-20	3	N/A	Very grassy bottom
L4	27	15	2	Rocky bottom primarily comprised of small rock. Scouring observed underneath concrete bridge
L5				Berm adjacent to stream provides some protection to adjacent homes
L6	150	undefined	undefined	Wetland plant indicators within undefined drainageway
L7				Concrete-lined channel adjoining unfinished 2-story home on man-made fill area

Source: Pedersen Planning Consultants, 1998

Sedimentation

Leafu Stream occasionally transports sediments into Leone Pala, particularly during and following heavier rainfall events. Through its hydraulic modeling of the Leafu Stream drainage, Pedersen Planning Consultants determined that a 10-year storm event generates a discharge of almost 70 tons of sediment into the lagoon. Roughly 121 tons of sediment are generated by a potential 100-year storm event (Table 7-5).

TABLE 7-5
SEDIMENT CONTRIBUTION TO LEONE PALA
10, 50, AND 100-YEAR STORM EVENTS
IN TONS PER STORM EVENT

Stream	10-Year Storm	50-Year Storm	100-Year Storm
Leafu	70	117	121

Source: Pedersen Planning Consultants, 1998

Higher velocity stormwater flows, which are generated from stormwater events, are the primary cause of erosion to stream banks. During a May, 1998 survey of the Leafu Stream drainage, the most noticeable example of such erosion was observed at cross-section L1. At this location, the stream had changed course and was continuing to erode the east bank of the stream. Local residents advised PPC representatives that a small bridge had been lost. A coconut log was installed by residents to replace the bridge.

Another cause for an increase in stream velocity is the hardening and narrowing of stream banks. As hardened stream banks gradually collapse, more sediment is discharged into Leafu Stream (Duffy, 1999).

In November 1999, the paving of an existing vehicular trail on the east side of Leafu Stream was in progress. This roadway improvement will likely discharge more sediment into Leafu Stream. As road drainage from heavier rainfall events occurs, new small drainage courses between the road and Leafu Stream will be formed in the future unless road drainage is collected via swales or other drainage facilities.

Leone Pala, which is situated at the seaward end of the Leafu Stream drainage, acts as a natural detention basin for surface runoff and sediments. Biosystems Analysis, Inc. reported that Leone Pala comprised approximately 20 acres of wetlands in 1991. This lagoon is generally shallow, but receives regular tidal exchange via a box culvert at the southwest end of the lagoon. This wetland plays an essential role in the detention of both sediments and nutrients that otherwise would discharge into the nearshore waters of Leone Bay.

The source of sediments is derived from more erosive soils along the upper Leone watershed. These include soils from the Oloava silty clay loam and Fagasa family-Lithic Hapludolls-Rock Outcrop Association. Along the lower Leafu Stream drainage, Leafu silty clay loam also contributes eroded soil material into Leafu Stream; however, this soil type has considerably less erosion potential than soils in the upper watershed.

Since Leone Pala provides an excellent detention area for sediments, it is important that the lagoon be conserved to maintain the overall size of the lagoon, as well as the wetland plants, e.g., red and oriental mangrove, that promote the detention of sediments. Volume 2 of the American Samoa Watershed Protection Plan recommends that ASEPA and ASDOC hold informal discussions with the landowner of a man-made fill area and deteriorating residential structure on the east side of Leone Pala. Such discussions should include, in part, considerations related to the potential reclamation of this area into the wetland.

In May, 1998, PPC observed a significant build-up of silt on north and east sides of the fill area. Surface flows from an unnamed drainage on the east side of the lagoon and other parts of the lagoon have apparently transported a significant amount of silt that will likely undermine the stability of the retaining wall around the perimeter of the man-made fill area.

Fish and Wildlife Resources and Related Water Quality

Fish and Estuarine Fauna

William Brewer & Associates made a reconnaissance of coral communities and other biological characteristics of Leone Bay in late March and early April, 1987. A limited part of this survey included a brief, walk-through survey of two channels within Leone Pala.

During the Brewer survey, estuarine fauna associated with the mangrove swamp included juvenile fresh-water prawns, the burrowing fiddler crab, and an intertidal littorine. A portunid crab was also observed within mangrove prop roots.

Within stream channels, mullet were also identified. In addition, local residents advised Brewer that Leone Pala represented a spawning area for mullet and atule.

Wildlife

In 1982, Amerson et al reported that there were some 44 resident birds in American Samoa. Approximately 19 of the 44 birds were land or waterbirds, 20 were seabirds, and five were introduced species.

Engbring and Ramsey of the U.S. Fish and Wildlife Service made a survey of forest birds in American Samoa in 1986. The Leone Pala area was not surveyed by these biologists. However, one local resident advised Engbring and Ramsey of his siting of ducks in the marshes in Leone (Engbring and Ramsey, 1986).

Aside from resident birds, there are some 15 migratory or vagrant species that occasionally frequent American Samoa. Four of these species are land or wetland birds. Consequently, the Leone Pala may also receive some use by some migratory wetland birds.

Conservation of Fish and Wildlife Resources

Adequate water quality is needed to sustain and enhance the spawning ground for mullet, atule, other fishes, invertebrates, and wildlife. As stated earlier, the conservation of these resources can most practically be pursued through the long-term conservation of Leone Pala and the wetland plants associated with the mangrove swamp portion of the lagoon. Because of the importance of Leone Pala as a spawning area and habitat for fish, invertebrates and wetland birds, two management recommendations are proposed:

- proposed land alterations and construction activities in Leone Pala should be prohibited by local traditional leaders and ASG agencies participating in the ASG project notification and review process.
- cost-effective opportunities for the establishment of additional mangroves and other wetland plants should be made within Leone Pala and/or the lower end of Leafu Stream in the vicinity of stream cross-section L6 (Figure 7-2).

In May, 1998, Colin (Orlo) Steele of ASEPA observed a number of wetland plant indicators along the marshy, lower end of Leafu Stream. These plants generally included Ludwigia, Hysopsiphla, L. actovalis, Hibiscus tiliaceus, Varringtonia samoensis, and Croix lacrema. While several residences are located near the lower end of Leafu Stream, it is believed that the planting of additional wetland vegetation in this area would enhance the residential area rather than adversely impact residential land uses. However, any such program would need to be closely coordinated with local residents and traditional leaders.

Water Quality Standards

Existing surface water quality standards were last adopted by the American Samoa Environmental Quality Commission in 1989. The standards applicable to Leafu Stream and Leone Pala are summarized in Table 7-6.

A possible revision to the surface water standards is under consideration at the time of this report. Under these standards, point source discharges, as well as the dredging and filling of wetlands is prohibited. Additional water quality criteria, i.e., light penetration and fecal coliform bacteria, is also established for all fresh surface waters (Table 7-7).

Water quality data along Leafu Stream was collected by ASEPA between October and December, 1995 as well as in April and May, 1996 to determine the variability of surface water quality from stream locations that were adjacent to different land uses, i.e., developed lands, agricultural, and undeveloped areas. For example, total suspended solids (TSS) levels at the stream location adjacent to developed lands were typically equal to or greater than TSS levels at stream locations adjacent to agricultural areas or undeveloped areas. Measurements of TSS and other water quality parameters at the stream location adjacent to agricultural land uses were usually greater than the levels at the station adjacent to undeveloped lands.

TABLE 7-6
SURFACE WATER QUALITY STANDARDS
APPLICABLE TO LEAFU STREAM AND LEONE PALA

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	5	NTU
Total Phosphorus	150	microngrams per liter
Total Nitrogen	300	microngrams per liter
Total Suspended Solids	5	milligrams per liter
Dissolved Oxygen	Not less than 75% saturation or less than 6.0 mgl. If the natural level of DO is less than 6.0 mgl, the natural level shall be the standard.	milligrams per liter
pH	Range between 6.5 to 8.6 and be within 0.5 pH units of that which would occur naturally.	pH

Source: American Samoa Environmental Protection Agency, 1989

TABLE 7-7
PROPOSED SURFACE WATER QUALITY STANDARDS
APPLICABLE TO ALL FRESH SURFACE WATERS

Parameter	Median Not to Exceed the Given Value	Units
Turbidity	5	NTU
Total Phosphorus	150	microngrams per liter
Total Nitrogen	300	microngrams per liter
Total Suspended Solids	5	milligrams per liter
Light penetration depth	>65 (50 % of the time)	feet
Dissolved Oxygen	Not less than 75% saturation or less than 6.0 mgl. If the natural level of DO is less than 6.0 mgl, the natural level shall be the standard.	milligrams per liter
pH	Range between 6.5 to 8.6 and be within 0.2 pH units of that which would occur naturally.	pH
Fecal Coliform	Shall not exceed a geometric mean of 100 per 100 ml in not less than four samples approximately equally spaced over a 30-day period, nor shall an sample exceed 200 per 100 ml in more than 10% of the samples.	Coliforms per 100 milliliters

Source: American Samoa Environmental Protection Agency, 1989

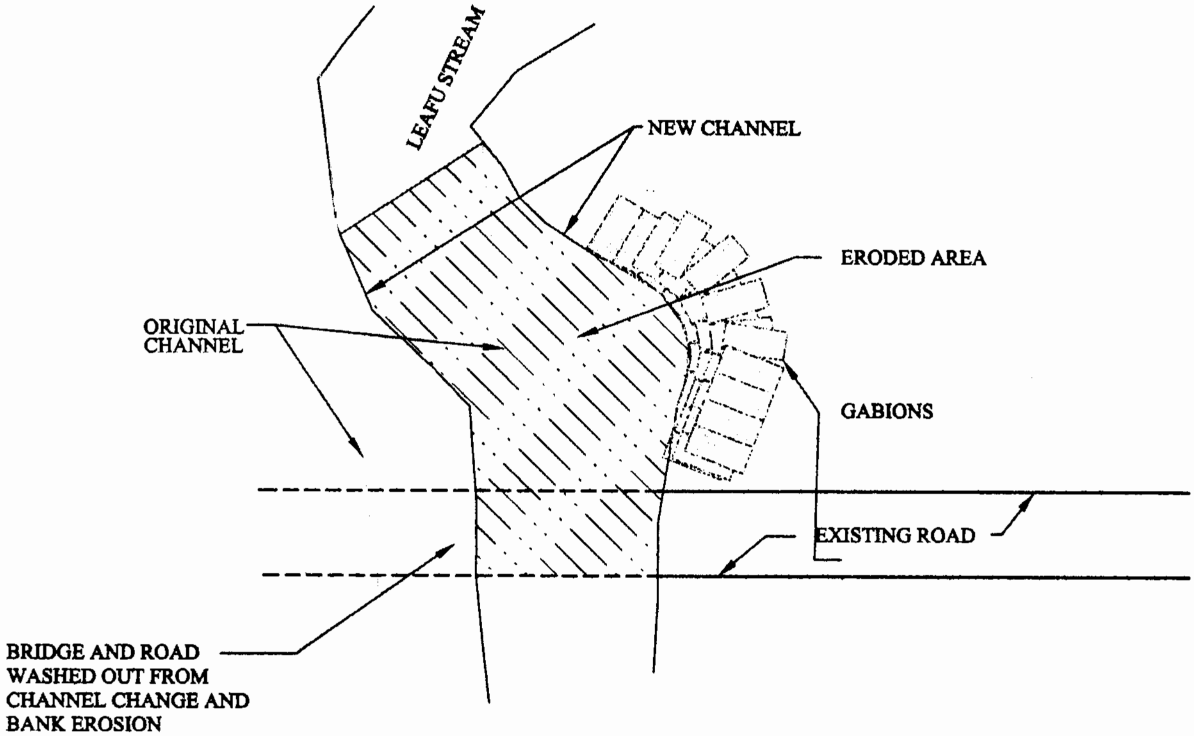
STORMWATER MANAGEMENT FACILITIES

No detailed inventory of the size of culverts and other stormwater management facilities was made to determine the adequacy of stormwater conveyance structures to accommodate future stormwater events. Rather, general observations were made of Leafu Stream channel at selected stream locations to identify sources and locations of ongoing and potential stream erosion, as well as determine practical improvements for the reduction of stream bank erosion and the downstream transport of sediments.

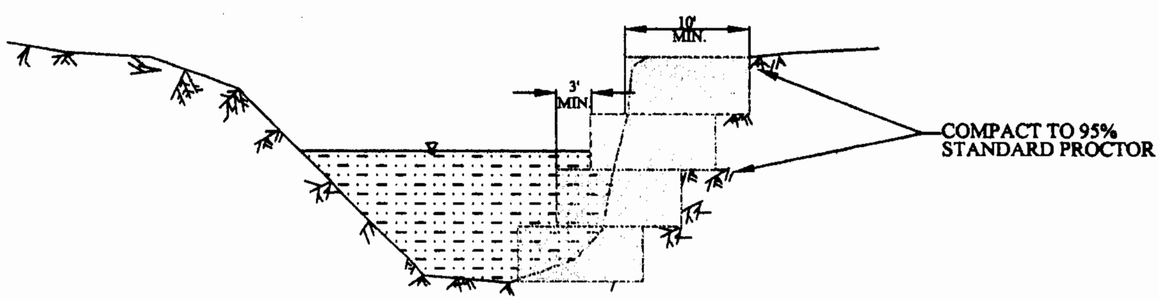
As stated earlier, significant stream bank erosion was observed at stream cross-section L1. The stream course had been altered and was eroding the east bank of the stream.

Recommended Facility Improvements and Estimated Costs

It is recommended that rock-filled, wire gabions be used along eroded stream banks in the vicinity of the L1 stream cross-section (Figure 7-3). The intended use of the gabions would be to stabilize failing or potentially erosive stream bank areas. The installation of gabions along roughly 100 linear feet of the stream is estimated to cost approximately $20,700 (Table 7-8).



TYPICAL PLAN VIEW



TYPICAL SECTION

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RECOMMENDED WIRE GABIONS
STREAM CROSS SECTION - L1

Scale: NA

Figure 7-3

TABLE 7-8
ORDER-OF-MAGNITUDE COST ESTIMATE
DEVELOPMENT OF STREAM CHANNEL IMPROVEMENTS
L1 CROSS-SECTION ALONG LEAFU STREAM

Item	Unit Cost	Quantity	Extension
Gabions (5Wx5Hx10L)	$140/LF	100	$14,000
Excavation	$20/LF	200	4,000
		Subtotal	*18,000*
		15% Contingency	*2,700*
		TOTAL	**$20,700**

Source: Pedersen Planning Consultants, 1999

Other locations of significant stream bank erosion may be present along the lower Leafu Stream drainage. These locations can only be identified via a walk-through of the entire length of the lower Leafu Stream drainage which was not the scope of the present study.

Recommended Maintenance of Stream Channel and Banks

Regular periodic maintenance of the stream channel and stream banks along Leafu Stream are required to enable the effective drainage of stormwater flows within the main stream channel, as well as the adjoining floodplain. Such maintenance will help reduce localized flooding and potential damages to adjoining residential properties. A practical maintenance program will involve the combined use of public works personnel and local residents.

ASG Public Works

It is recommended that a four-person crew be organized by the ASG Department of Public Works to clear trash and other obstructions from lower Leafu Stream, at least, two times per year. This crew should remove vegetation, garbage, and other debris that constrain or reduce stormwater flows within the stream channel. Such maintenance should extend approximately 10 feet from the top of the stream bank.

The Public Works crew will require the following equipment to perform such maintenance:

- weed-eaters and machetes that can be used to clear vegetation;
- sledge hammers, picks, shovels, and rakes that can be used to remove obstructions and debris from stream course areas immediately adjacent to culvert inlets and outlets;
- a pressurized water source, e.g., pumper truck or fire hydrant, and quick-disconnect hose that can be used to clear debris inside closed culverts; and,
- a small truck to haul collected solid waste material and garbage from Leafu Stream.

Residents Living Adjacent to the East and West Sides of Leafu Stream

Leone residents, who live adjacent to the east and west sides of Leafu Stream, can continue to maintain the Leafu Stream floodplain by the regular maintenance of lawn areas, trees and shrubs that are located within the 100-year floodplain determined by the Federal Emergency Management Agency. Observations made in May, 1998 indicate that many residents already carry out such maintenance on a periodic basis. In addition, many homes are set back a considerable distance from Leafu Stream.

STORMWATER DETENTION OPPORTUNITIES

In view of existing residential, commercial, and community land uses, stormwater detention opportunities along Leafu Stream are limited. The development of additional areas for stormwater detention is also unnecessary given the opportunity afforded by Leone Pala. However, this conclusion assumes a long-term conservation of Leone Pala which represents the only practical opportunity for long-term detention of sediments from stormwater flows.

Since 1961, at least half of Leone Pala has gradually been filled to accommodate other agricultural and residential land uses. The designation of the Leone Pala as a special management area in 1990 has enabled the ASG Department of Commerce, Coastal Management Program, to perform detailed reviews of proposed land uses within Leone Pala and, ultimately, curtail most land use development.

Despite these resource management measures, a man-made island was developed on the east side of Leone Pala in the early 1990's. As stated earlier, it is recommended that the man-made island and residence be removed from the lagoon. This improvement, which would reclaim land formerly in Leone Pala, should be pursued in coordination with representatives of the landowner.

Whether or not landowner representatives are receptive to this recommendation, the island is in danger of being enveloped with sediment. The slope of Leafu Stream becomes relatively flat along this reach of the stream; consequently, sediments tend to drop out and collect in and around this obstruction. In May, 1998, PPC determined that the upstream boundary of the man-made island has filled to approximately one foot from the top of the island. While this filling continues, the sediment can be expected to progress down stream and gradually reclaim the man-made island within Leone Pala. As this occurs, the stream will likely fill in until a localized equilibrium is achieved causing a reduction in stream width and, possibly, creating additional velocity problems adjacent to the island or further downstream. Local equilibrium may occur within a 5 to 10-year period.

STREAM RESTORATION AND ENHANCEMENT OPPORTUNITIES

Lower Leafu Stream Drainage

Site Location

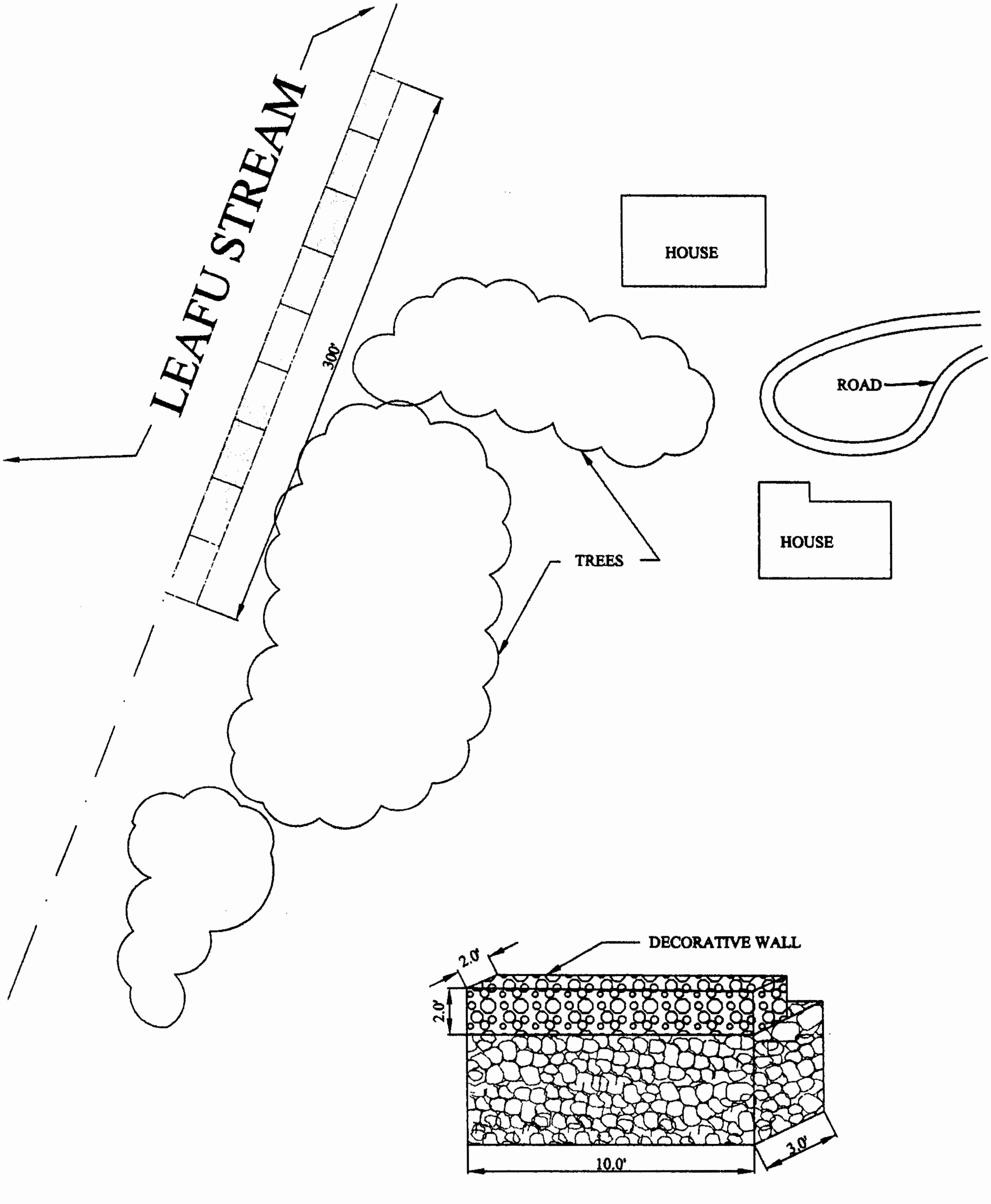
A potential stream restoration and enhancement opportunity is located at the lower end of Leafu Stream just prior to its discharge into Leone Pala. In the vicinity of stream cross section L6, Leafu Stream is a wet, marshy area that already contains a variety of wetland plants and other vegetation (Figure7-2). The stream channel has limited definition and actually represents the lower end of Leafu Stream and an unnamed tributary on the west side of Leafu Stream.

A few residences lie west of stream cross-section L6. No land uses are present within the lower end of the drainage.

General Design Concept

Immediately west of existing residences and lawn areas, a trench would be excavated along 300 linear feet of the drainage area. A basaltic rock wall would be constructed within the trench using wire gabions approximately 4x3x10-feet in size to better define the east side of the stream and help direct future stream flows. Some basaltic rock treatment would be made on the east side of the wall to ensure that the wall would be attractive and complement existing residential development. The wall would also be back-filled with native soil to reduce the visual impact of the wire gabions (Figure 7-4).

West of the proposed wall, the stream would be enhanced through the planting of various wetland plants which would be selected by representatives of the ASG Environmental Protection Agency and American Samoa Community College, Land Grant Program. The selected plants should help facilitate the long-term deposition of sediments, establish and possibly restore a more defined stream course, and increase aquatic and wildlife habitat.



GABION WITH DECORATIVE WALL

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RECOMMENDED STREAM ENHANCEMENT
STREAM CROSS SECTION - L6

Scale: NA

Figure 7-4

Project Development Costs

Construction of the proposed wall would cost roughly $33,000. These costs are summarized in Table 7-9.

TABLE 7-9
ORDER-OF-MAGNITUDE COST ESTIMATE
CONSTRUCTION OF WALL AND RELATED STREAM ENHANCEMENT
ALONG LOWER END OF LEAFU STREAM

Item	Unit Cost	Quantity	Extension ($)
Gabions (3Wx4Hx10L)	$35/LF	100	$10,500
Trench Excavation	$6/LF	300	1,800
Top Soil Embankment	$25/LF	300	7,500
Decorative Wall	$30/LF	300	9,000
		Subtotal	*$28,800*
		15% Contingency	*4,320*
		TOTAL	**$33,120**

Source: Pedersen Planning Consultants, 1999

Potential Project Benefits

The development of a wall and the establishment of more wetland plants can be expected to improve general stream hydrology, as well as increase the amount of area for sediment deposition. Since some eutrophication of the lower stream drainage is already taking place, the establishment of wetland plants will likely enhance definition of a stream channel. This definition will, in the long term, facilitate the discharge of stormwater flows into Leone Pala. In the absence of these improvements, greater eutrophication in the area will probably lead to increased flooding of adjacent residential properties.

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